Bought at Old South Bookstore
October 13, 1909
for 5 cents
E. E. Southard

ANATOMY OF THE BRAIN.

WORKS

Published by the same Author in English.

---

1. Phrenology, or the Doctrine of the Mind.
2. Philosophical Principles of Phrenology.
3. Outlines of Phrenology.
4. Elementary Principles of Education.
5. Observations on Insanity.
6. Examination of the Objections made in Great Britain against Phrenology.

Ready for the Press.

Illustrations of Phrenology in Connexion with the Study of Physiognomy. Part I.—Characters, with 34 plates.

THE

ANATOMY OF THE BRAIN,

WITH

A GENERAL VIEW

OF THE

NERVOUS SYSTEM.

BY

G. SPURZHEIM, M.D.

OF THE UNIVERSITIES OF VIENNA AND PARIS; LICENTIATE OF THE ROYAL COLLEGE OF PHYSICIANS IN LONDON.

TRANSLATED FROM THE UNPUBLISHED FRENCH MS.

BY R. WILLIS,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS IN LONDON.

WITH ELEVEN PLATES.

LONDON:

PUBLISHED BY S. HIGHLEY, 174, FLEET-STREET,

and Webb-Street, St. Thomas's Hospital;

SOLD ALSO BY HILL AND SON, EDINBURGH; AND CHARLES ARCHER, DAME-STREET, DUBLIN.

MDCCCXXVI.

LONDON:
PRINTED BY WILLIAM CLOWES,
Northumberland-court.

CONTENTS.

PAGE

Preface vii

Section I.—General Considerations 1

Of the Existence of the Pulpy and Fibrous Substances 2

Of the Structure of the Two Nervous Substances . 3

Of the Use of the Pulpy Nervous Substance . 6

Of the Origin of the Nervous System . . . 10

Of the Mode of Formation of the Nervous System . 16

Of the General Form of the Nervous System . 18

Of the Structure and Use of Ganglions . . . 19

Section II.—Division of the Masses composing the Nervous System 23

Section III.—Of the Nervous Masses of Voluntary Motion, and of the External Senses . . 36

Of the Nervous Mass of the Vertebral Column . 50

Of the Pretended Cerebral Nerves . . . 68

Of the Quadrigeminal Bodies 83

Section IV.—Of the Best Method of Dissecting the Brain 95

Section V.—Of the Cerebellum 106

Section VI.—Of the Brain 143

Decussation of the Anterior Pyramids . . 146

Two portions of the Crura and Cerebral Masses . 153

PAGE
Comparative Anatomy of the Brain . . . 159
Structure of the Convolutions 163
Section VII.—Of the Commissures of the Nervous Apparatuses 178
Section VIII.—Of the Communications of the Nervous Apparatuses 195
Section IX.—Of the Anatomico-Physiological Relations of the Nervous Apparatuses . . . 204
Explanation of the Plates and Figures 216

PREFACE.

The affective and intellectual faculties of man, both in their healthy and diseased condition, are unquestionably dependent on the body; and, among the various branches of anthropology, anatomy is the basis of all the others. The organic apparatuses, which are indispensable to the mental manifestations, consist of the brain, cerebellum, spinal cord, and the nerves of the external senses and voluntary motion. To make known the structure of these parts is the special object of this volume.

History proves that the structure and destination of the nerves were long unknown. Hippocrates and Aristotle, for instance, confounded, under the same general title, ligaments, tendons, nerves, and even blood-vessels. Hippocrates believed that the nerves terminated in muscles and bones, and produced voluntary motion. Herophilus, who lived nearly three centuries before the com-

mencement of the vulgar era, was the first who discovered the connexion of the nerves with the brain, and who looked on them as the instruments of sensation. Erasistratus divided the nerves into those of sensation and those of motion; the first he derived from the brain, the second from the membranes. Galen held that the nerves of sensation arose from the brain, and those of voluntary motion from the spinal cord. In the sixteenth and succeeding centuries the brain and nerves were subjects of much research, but it is only in our own times that they have begun to be understood,—that their true structure has been discovered, and that new and unthought-of functions have been proved to belong to them.

The nervous being the most delicate tissues of the body necessarily required extremely careful and often-repeated examination to be understood, and this they could not receive during ages when prejudice opposed insurmountable obstacles to the dissection of dead bodies. It is therefore easy to conceive why such slow progress was made in the anatomical knowledge of the nervous system.

Dr. Gall is the original author of a new physiological doctrine of the brain. The discovery of the ground-work of this is all his own, and he had even gone very far in rearing the superstructure before the year 1804, when I became his colleague. From this period we continued labouring in common until 1813, when our connexion ceased, and each began to pursue the subject for himself. The works which Dr. Gall has published in his own name fix the extent of his phrenological knowledge. My ideas, too, are developed in my own publications: history will assign to each of us his share in the works that have issued under our joint names.

It was in the year 1800 that I attended for the first time the private course of lectures which Dr. Gall had been in the habit of delivering occasionally at his house for four years. At this time he spoke of the necessity of the brain to the manifestations of mind, of the plurality of the mind's organs, and of the possibility of discovering the development of the brain by the configuration of the head. He pointed out several particular organs of different memories, and of several sentiments, but he had not yet begun to examine the

structure of the brain*. Between 1800 and 1804 he modified his physiological ideas, and brought them to the state in which he professed them at the commencement of our travels†.

Dr. Gall having met with a woman, fifty-four years of age, who from her infancy had laboured under dropsy of the brain, and who, nevertheless, was as active and intelligent as the generality of females in her own rank of life, and being convinced that the brain was the indispensable organ of the soul, expressed himself in terms similar to those which Tulpius had used before him, on observing a person afflicted with hydrocephalus, who exhibited good intellectual faculties, *viz.*, the structure of the brain must be different from what it is commonly supposed to be. He now felt the necessity of examining the mind's organ anatomically. As his medical practice occupied his time, he employed M. Niclas, a student, to dissect for him; but the

* Exposition de la Doctrine de M. Gall, par Froniep, 3me edit. 1802.

† Bischoff Exposition de la Doctrine de M. Gall, sur le Cereau et le Crane, Berlin, 1805; et Blœde, la Doctrine de Gall sur les Fonctions du Cerveau, Dresden, 1805.

spirit of this gentleman's researches was merely mechanical, as is allowed in our joint work, entitled "Anatomie et Physiologie du Systême nerveux en général, et du Cerveau en particulier *."

Having completed my studies in 1804, I was associated with Dr. Gall, and devoted myself especially to anatomical inquiries. At this period, Dr. Gall, in the Anatomy, spoke of the decussation of the pyramidal bodies, of their passage through the pons Varolii, of eleven layers of longitudinal and transverse fibres in the pons, of the continuation of the optic nerve to the anterior pair of the quadrigeminal bodies, of the exterior bundles of the crura of the brain diverging beneath the optic nerves in the direction which Vieussens, Monro, Vicq d'Azyr, and Reil † had followed, the first, by means of scraping, the others, by cutting the substance of the brain. Dr. Gall shewed further, the continuation of the anterior commissure across the striated bodies; he also spoke of the unfolding of the brain that happens in hydrocephalus. The notion he had conceived of this, however,

* Preface to the first vol. p. 16.

† Gren's Journal, 1795, i. p. 102.

was not correct; for he thought that the convolutions resulted from the duplicature of a membrane, believing that the cerebral crura entered the hemispheres on one side, expanded there, and then folded back on themselves by the juxtaposition of the convolutions. The true structure of the convolutions, and their connexion with the rest of the cerebral mass, were not described until our joint Memoir was presented to the French Institute in 1808.

The mechanical direction which the anatomical investigations had taken did not appear to me satisfactory. Guiding myself in my inquiries by physiological views, always comparing structure with function, I discovered the law of the successive additions to the cerebral parts; the divergence in every direction of the crural bundles towards the convolutions; the difference between the diverging fibres and those of union; the generality of commissures; the true connexion of the convolutions with the rest of the cerebral mass, and the peculiar structure which admits of the convolutions being unfolded (an event that occurs in hydrocephalus of the cavities), whilst the mass lying at their bot-

toms, and belonging, for the most part, to the apparatus of union, or of the commissures, is pushed by the water between the two layers composing them; lastly, I demonstrated the structure of the nervous mass of the spine, and I flatter myself with having arrived at the best method of dissecting the brain, and exposing its parts.

What is my object then in publishing this volume? Our large work is too expensive for the generality of medical students, and, further, the method pursued in the discussions there is only calculated for professed anatomists; whilst this book will be both less costly, and it will be adapted to the student as well as to the more advanced anatomist. Moreover, many new ideas, possessing a great share of interest, may now be added; for since Dr. Gall and I first published, the study of the nervous system has engaged the especial attention of anatomists and physiologists. I have, myself, continued inquiring, and conceive that I have made several new discoveries. I have, however, copied some passages from the first volume of the large work already mentioned, and also given reduced drawings of several of its

plates; because I think I have acquired a right to this volume, by its publication in our joint names, by my discoveries that form its principal object, and by all I did in furtherance of its publication. All the drawings were executed under my superintendence from anatomical preparations, made and determined on by me; the engraver worked by my directions; no plate was sent to press without my approval; the descriptions of the plates, and the anatomical details are mine; and I furnished the literary notices in regard to the nerves of the abdominal thorax, to those of the cerebral column, of the five senses, of the cerebellum, and of the brain.

Whoever desires more copious historical details than this volume will be found to contain, I refer to our Memoir, addressed to the French Institute, and to the first volume of our great work, commenced in common, and continued by Dr. Gall singly, after the middle of the second volume.

The influence our labours have had on the study of the nervous system is incontestable. To be convinced of this, it is enough to examine the state of knowledge in regard to the anatomy, physiology, and pathology of the

brain and spinal marrow, when Dr. Gall and I developed our ideas on these matters, whether it was by teaching orally, by dissecting publicly, or by means of our writings. I confess there is great satisfaction in the consciousness of having contributed to the important reform that has been effected in regard to the nervous system. I am only sorry to observe, that many of our ideas are appropriated by the authors of recent publications, without any mention of the source whence they were derived, or of the individuals who first struck them out, or reduced them to certainty by direct proofs. We are commonly enough mentioned, it is true, when such of our assertions as appear weak are the subjects of criticism, but our names are kept in the background when points of importance become the matter of discussion. The public, for instance, by referring to the proper place, may judge whether Mr. J. Cloquet, in his "Anatomy of Man," has been sufficiently explicit in stating, that he has copied every one of the plates of the human brain contained in our large work. M. Serres, whose Memoir was deemed worthy of its prize by the Academy of Sciences of

Paris, in the first volume of his work, uses our names no fewer than fifteen times, in connexion with a *single idea,* which he fancies he can refute; and generally along with every fact that looks unfavourable to our opinion, he names us, but he always forgets to cite us in relation to very many fundamental conceptions which we had announced at the same time. They who have written to the following effect:—" M. Serres has proved clearly the erroneousness of M. Gall's observations, and replaced them by others," may undeceive themselves by attending to the remark I have just made.

M. Serres's publication forces me likewise to request the reader to distinguish between a multitude of words and facts on the one hand, and the corollaries which result on the other. I agree with those who, in works of science, pay especial regard to truths demonstrable to others, to ideas available in practical life, and to clearness and simplicity of style. To what purpose may serve the following passage, which occurs in the preliminary discourse of M. Serres, where, after having said that a monster may be a vegetation of its like, that it may have

two heads, two tails, and six or eight extremities, but that it would remain strictly confined to the limits of its class, he exclaims :—" *This wonderful phenomenon is undoubtedly connected with the general harmony of creation. What may be its cause? We know it not, and in all likelihood we shall remain ignorant of it for ever. It is one of the mysteries of creation, whose surface is meted by man, but whose depths are sounded, and known to God alone* *."

This phenomenon does not appear to me more extraordinary than that a kitten is not a puppy, or that the crab-tree does not produce pears. If the egg of a bird in its ordinary state cannot produce a mammiferous animal, why should the germ of this same egg, if it chance to be imperfectly developed, produce a deformity like to one of the mammalia? Were the case thus, there would be some cause for an amazement, but the universal fact of every animal producing its kind,

* " Cet étonnant phénomène est sans doute lié à l'harmonie générale de la création. Quelle peut en être la cause? Nous l'ignorons et vraisemblablement nous l'ignorerous toujours. C'est un des mysterés de la création, dont l'homme mesure la surface, mais dont Dieu seul sonde et connait la profondeur."

is not, in my eyes, more astonishing than any other natural event.

Further, the mass of facts cited, the number of dissections made, ought never to impose on us, nor be made a means of concealing the truth. Many of the anatomists who had lived before us dissected some hundreds of brains, and they made a boast of their doings in this way; but they did not perceive that which I pledge myself to have discovered before I had dissected a dozen; for instance, the successive additions to the cerebral parts, and the two kinds of fibres, to wit, the diverging, and the fibres of union. Anatomists and physiologists had certainly looked upon heads without number; but before Dr. Gall's appearance, had failed to discover the seat of a single cerebral organ. A solitary individual, a beggar, enabled him to detect the organ of self-esteem, precisely as the fall of a single apple revealed the law of gravitation to Newton. Anatomists had seen many human brains without remarking any differences among them; these, however, are, to say the least, as constant as similarities. The point that essentially interests science is, *the*

discovery of the truth, and this is then *confirmed* and established by all ulterior observations.

The anatomy of the peculiar system necessary to the affective and intellectual manifestations, as well as anatomy in general, admits of consideration in several ways.

First, it is simply descriptive, that is, physical appearances alone are examined, such as the form, the size, and colour of parts, the tissues which compose them, and their connexions.

The nomenclature of the encephalon, of itself suffices to shew that such views had principally guided anatomists in their study of its structure. We still speak of the brain, of the cerebellum, of hemispheres, lobes, convolutions, and anfractuosities; of a fornix, an infundibulum or funnel, and of pisiform and striated, and quadrigeminal and pyramidal, and olivary and harrow-shaped bodies; of a pineal gland, of a hippocampus's foot, of a writing-pen, and many other parts, some with very offensive names. Such views are easily conceived to be but little useful in medicine. This is the reason why the gene-

rality of practitioners are satisfied with knowing the membraneous envelopes of the encephalon, the large blood-vessels, the sinuses, the great masses of the brain and cerebellum, and the principal cavities. Of these views, however, I shall only take such notice as may be necessary to recognize the parts spoken of in my physiological and pathological considerations.

M. Serres, in the first page of his work on the Anatomy of the Brain, says, "Up to the present time, (1824,) no one has dreamt of uniting into a body of doctrine all the knowledge acquired on the anatomy, the physiology and the pathology of the brain and nervous system. I enter on the attempt to overtake this vast subject*." Dr. Gall's and my own works belie this assertion, and they have only to be consulted to prove that all our inquiries were directed into this very channel. We have constantly insisted on the importance of studying the nervous system under all relations at once. From the year 1817 to 1823,

* "Jusqu'à ce jour (1824) personne n'a songé à réunir en corps de doctrine les connaissances acquises sur l'anatomie, la physiologie et la pathologie du système nerveux. Je vais essayer de parcourir ce vaste sujet."

I regularly delivered "*a Course of Lectures on the Anatomy, Physiology, and Pathology of the Brain and External Sènses,*" twice a year. My course was always so announced, according to the custom in Paris, by public placards; and my auditors must recollect that in my introductory discourse, I uniformly insisted on the importance and necessity of studying these branches in connexion. From the above, it will be evident that M. Serres was mistaken when he published himself "the *first* to attempt to overtake (*essayer de parcourir*) this vast subject." Nevertheless, I most willingly allow that the principal consideration is not the having been the first to examine the nervous system: the true merit of the inquirer consists in that which he has effected, that which he had discovered, and justice in these particulars will, in time, be assuredly rendered to all. If, on occasion, I seem more especially solicitous in shewing the erroneousness of M. Serres's opinions, it is only because these have received the sanction of the French Institute, whose influence is great over the public mind.

2. Anatomy is physiological, when the

structure of parts is studied in relation to their functions. This kind of anatomical knowledge is essential to practical medicine; for without it, the seat of deranged functions cannot be understood. For this reason, therefore, my anatomical details will always be given in harmony with the physiological ideas I entertain of the apparatus destined to the manifestation of the affective and intellectual faculties.

3. Anatomy is peculiarly human, or, it comprehends the other beings of creation. In the latter event, it is entitled *comparative* anatomy, and this is a field that possesses much interest for the anatomist, physiologist, and practical physician; I shall, therefore, enter upon it at frequent intervals, always with the view of advancing the knowledge on the affective and intellectual nature of man.

4. Anatomy is entitled *pathological*, when it treats of the organic changes undergone by parts whether examined in connexion with, or independently of, their deranged functions. Inquiries in this direction belong less to the present volume, than to that I have published

on Insanity. To it, therefore, I refer the reader for details.

The object of this compendium, then, is to present the principal views that may be taken of the physiological and comparative anatomy of the apparatus destined to the affective and intellectual manifestations. It will be found divided into nine sections:—in the first, I make some general reflections on the nervous system; in the second, I speak of the division of the nervous apparatuses; in the third, I treat of the nerves of voluntary motion and of the external senses; in the fourth, I discuss the best mode of examining the structure of the brain; in the fifth, I describe the cerebellum particularly; in the sixth, I do the like in regard to the brain; in the seventh, I examine the commissures; in the eighth, the communication of the nervous parts with each other; and in the ninth, I go into some anatomical points connected with physiology. The work will prove that I rather adhere to philosophical views and principles, than to mere description of the physical qualities belonging to individual masses, although this last be the most common, I might almost say

the only, plan that is generally pursued. I have endeavoured, in an especial manner, to class together the parts that constitute particular apparatuses, a practice which to our predecessors was entirely unknown, as is abundantly evident from their nomenclature of the brain and its parts.

ANATOMY OF THE BRAIN,

&c.

Section I.

General Considerations.

Nerves are whitish cords that pervade the bodies of the more perfect animals; they are always made up of many filaments, each of which, however minute, is a tube that holds in its interior a peculiar pulpy substance, constituting one among the elements of organization. It is to a multitude of such tubular filaments, enveloped in a common sheath, that the term *nervous cord,* or *nerve,* is usually applied. These cords, as well as their component filaments, vary much in thickness and consistency. The last quality depends entirely on the texture of the enveloping membrane.

The nervous system comprises two distinct substances: the one gelatinous or pulpy, and usually of a grayish or brownish hue; the other fibrous, and of a more or less perfect white

colour. They are commonly spoken of in books as the cineritious and medullary substances.

Of the Existence of the Pulpy and Fibrous Substances.

Comparative anatomists are not agreed upon the constantly-conjoined existence of the two nervous substances. Some admit the presence of the white without that of the gray, especially in the spinal mass of many inferior animals, as reptiles and fishes. The nervous ganglions of the *asteriæ* are also said to contain no gray matter.

The above observation is evidently made in consequence of more attention being given to the colour than to the essential nature of the pulpy substance. Pulpiness, not colour, is its distinguishing character. There are animals whose humours, or, as was formerly said, whose blood is white. The essential consideration is evidently, in this case, the existence, not the colour, of the nutritious fluid. Should it not also be so in regard to the first or pulpy nervous substance, which in the majority of animals is of an ash-gray or brown colour? Undoubtedly it should, for it is well known to vary in complexion, not only in different species of animals, but even in individuals of the same kind, according to their state of bodily health. The pulpy substance is

commonly extremely pale in the brains of those who die of dropsy or pulmonary consumption.

The pulpy substance is found in the ganglions, and in the nervous masses of the head and spine of vertebral animals. In the mammiferous classes especially, it occurs on the surface of all the convolutions of the brain and cerebellum, (a circumstance from which it derives its title, *cortical,*) in the masses called striated bodies, and optic thalami, in the interior of the crura of the brain, of the annular protuberance, of the dentated body, of the cerebellum, of the medulla oblongata, of the spinal cord through its entire length, and of all the ganglions of the body. It never of itself composes an isolated unit or whole, it is always in connexion with the white or fibrous substance. Occasionally it lies in masses of varying magnitude, and again it occurs in layers, or it runs along in slips following the nerves in their course.

Of the Structure of the two Nervous Substances.

The first nervous substance is pulpy or gelatinous, and of a colour varying from deep brown to pale ash-gray or white. Its intimate structure is unknown. Ruysh, Vieussens, and almost all the cotemporaries of Haller, regarded it as a tissue of very fine blood vessels. Ackermann of Heidelberg, and Walter of Berlin, in our own

times, have held it to consist of an extremely-attenuated prolongation of vessels, in the course of becoming still more minute, ultimately to compose the white or fibrous substance. This is a very ancient idea; it may be traced as far back as the age of Praxagoras, who fancied that the nerves originated where the arteries ended. Albinus, and, at a later period, Sœmmerring, have proved by their injections, that besides very minute blood-vessels, there also exists a peculiar substance in the cineritious nervous mass. The first or pulpy substance, therefore, can only be said to have an immense quantity of blood-vessels distributed through it.

Vicq d'Azyr believed that he could trace fibres in the pulpy substance; but what he saw was the white or truly fibrous substance, intermingled or uniting with the gray.

The second, or white, nervous substance, is essentially fibrous, but it varies much in its degrees of consistency. Anatomists have differed extremely in their notions of its intimate structure. Some have maintained it to be solid, others have said that it was tubular. Some have found it, like the pulpy substance, composed of globules; and whilst some have held it possessed of no blood-vessels, others have argued for its entire composition of these.

Lewenhœck, Vieussens, and Steno, believed that the white nervous substance was fibrous.

This is the opinion which Dr. Gall and I have espoused. By scraping it in the brain according to the direction of its fibres, these may be seen with the naked eye, and if the scraping motion be oblique or transverse to their course, they will be seen to be drawn from their natural direction, or to be torn. If the brain be boiled in oil, or macerated in diluted nitric or muriatic acid, or in vinegar, or alcohol, or if it be frozen, the fibrous structure of its white substance will be rendered extremely apparent. Some, however, say, that the fibrousness is then the consequence of a chemical change. As the same result, however, is constantly obtained, and as the fibres, whichever of the processes be employed, are regularly disposed in corresponding situations in a similar manner, the fibrous structure must of necessity be recognised as natural and inherent.

A few authors have attributed the fibrous appearance of the white substance to the impressions of blood-vessels. This mistake may be detected at once by comparing the course of the blood-vessels with that of the cerebral fibres.

The reality of the fibrousness of the white substance is further opposed, by saying that when the brain is cut, it does not appear, and that it is produced by the force employed to tear the tougher cerebral masses asunder.

To this I reply, that it is impossible, by means

of a clean and smooth cut, to discover the structure of any extremely delicate and soft part whatsoever. Such a method is not even available in those cerebral parts that are incontestably fibrous, as the pyramidal bodies, the annular protuberance, the peduncles of the brain, &c.

M. Bogros, of Paris, read a paper to the Academy of Sciences, on the 25th of May, 1825, in which he maintained that every nervous fibre is perforated by a canal from its origin to its extreme termination. The accuracy of this statement is far from being ascertained.

The white nervous substance is generally called *medullary*. This name, however, ought to be discontinued for two reasons: in the first place the idea we form of marrow excludes the conception of fibrousness; and again, the functions of the nervous fibres are so superior to those of the marrow, that it is a pity to designate both by the same word. The name is evidence of the error that was anciently committed, when every thing contained in an osseous cavity was considered as marrow.

Of the Use of the Pulpy Nervous Substance.

Different opinions have prevailed ever since the times of Vesalius and Piccoluomini, who directed the attention of anatomists in a particular manner to this subject, respecting the use and

destination of the pulpy or gray substance. It has frequently been regarded as an organ of secretion, whether of vital spirits or of a nervous fluid. Unity of sentiment, it is probable, will not be readily obtained upon this particular point: but seeing that the rudiments of each new shoot in trees are developed in a deposition of mucilaginous-looking matter; that the cartilages in animal bodies are successively liquid, gelatinous, and cartilaginous, and that several turn into firm bone; that anatomists, in many instances, have agreed in deriving the nerves from ganglions; that the brain, too, is at first fluid, then gelatinous, and ultimately fibrous; in fine, that the pulpy nervous substance is always found where the white fibres become more numerous; that these are implanted, so to say, into it, and that a great quantity of blood-vessels are expanded on it; Dr. Gall and I have said, that to us it appears to be the source or nourisher of the white fibres. Let us, however, distinguish in this, as in every other place, between facts and inferences. Supposing that our ideas concerning the inference were really inexact, the peculiarities I have mentioned, and the essential importance of the pulpy substance to the nervous functions, must ever be admitted.

Having said that a gray colour is not an essential in the character of the pulpy substance, no objection to our notions of its uses can be derived

from the fact of its supposed absence in the ganglions of the *asteriæ*. A gelatinous or pulpy matter does certainly enter into their constitution, and this is sufficient.

The white substance is also said to be present in the brain and spinal cord before the pulpy or gray appears. If by this the existence of the nervous masses that become white prior to an evident separation into two substances, and to the developement of convolutions, be understood, I agree; but if the rudiments of the brain, cerebellum, and spinal cord, be said to be white, and not gray in the first instance, I positively deny the assertion. The nervous masses of the head and spine are pulpy or gelatinous, and decidedly grayish in colour before they are white. Neither Dr. Gall nor I have ever thought of saying, that the portion of the completely-developed nervous system, which is pulpy and gray, gives birth to that which is white and fibrous. We did but intend to announce the fact of a gelatinous and grayish state of the brain preceding its fibrous and white condition, precisely as we should say of its entire mass, that it is liquid before it becomes gelatinous.

Our idea of the formation of the nervous system seems more especially plausible, when it appears to be perfectly analogous to what takes place in the osseous. Bone begins by being gelatinous, it is then cartilaginous, and ultimately solid and

earthy. I repeat, however, that no one can be more impressed than myself with the difficulty of drawing general conclusions; I am, therefore, very far from anxious to impose such as I do infer upon others. I only insist on the necessity of exactness in regard to the facts related. Putting our theory of the formation out of the question entirely, then, Dr. Gall and I still assert our title to be considered as the first who discovered and made known the general relation that prevails in man and the mammalia, between the pulpy and fibrous substances of the brain and its several parts.

Messrs. Foville and Pinel Grandchamp have of late inferred, from pathological observations, that the superficial cineritious substance of the brain presides over intellectual functions, and its white and deep-seated gray mass over locomotion.

I am disposed to set much store by pathological observations, yet I do not see that we dare place unlimited confidence in them alone. Truth is, I conceive, universally harmonious; truth consequently cannot have been attained in any case until anatomy and physiology and pathology accord exactly. Now, who will maintain that the locomotive powers of animals are great in proportion as their brains contain more of the white nervous substance, and as the striated bodies and the supposed origins of the optic nerves

(thalami) are large? Or who will say that the locomotive capacities of inferior tribes, in whose brains the gray substance predominates, are less remarkable than their intellectual endowments? These positions are alike untenable. Dr. Gall and I suppose that each nervous apparatus is composed of the two peculiar substances, the pulpy and the fibrous, and that both are necessary to produce an instrument adequate to perform a particular function.

Of the Origin of the Nervous System.

The brain has very generally been regarded as the sole and common origin of every part of the nervous system. Even the old anatomists, who classed the brain along with the viscera of the chest and belly, and treated of its structure in their chapter of Splanchnology, mistook it, however strange the error may seem, for the source of all the nerves. In their eyes, the spinal cord was a prolongation of the cerebral mass, and the great sympathetic, and the nerves of the abdomen and thorax, were continuations of the encephalon and spinal cord. This erroneous view, as it was espoused, was especially defended, by observing that the commands of the will issued from, and that all consciousness resided in, the brain. These facts, however, do, in truth, prove no more than the communication of the nervous

masses of the body with those of the head. The muscular fibres, we see, are excited by the nerves, but they are not, therefore, continuations of the nervous filaments.

The notion, however, was so palpably erroneous, that anatomists were not long in calling its soundness in question, more especially in regard to the nerves of vegetative life. Winslow *, for instance, separated the great sympathetic from the spinal cord and brain; he even regarded the bundles that run between its ganglions or masses, as simple branches of communication; and went so far as to say, that all the ganglions ought to be considered as peculiar origins of nerves, and, consequently, as so many little brains.

Sœmmerring likewise observes, that the sympathetic, having an independent existence, may rather be said to go to, than to come from, the spinal cord. He adds, that it never forms a trunk in any wise proportionate to the number and size of its communicating branches, and that it never loses itself among muscles, but follows the course of the blood-vessels †.

Bichat has expressed his opinion in the most positive manner upon this subject. "The ideas of anatomists," says he ‡, "upon this important nerve, seem to me very little accordant with what

* Anatomy. † Hirn und Nerven.
‡ Sur la Vie et la Mort.

nature proclaims to be just. All agree in representing it as a medullary cord, extending from the head to the os sacrum, sending various branches, in its course, to the neck, the chest, and the abdomen; having, in short, a distribution analogous to the spinal nerve, from which, or from those of the neck, it is said by some to derive its origin. Whatever the name chosen to designate it may chance to be, sympathetic, intercostal, trisplanchnic, the mode of considering it will still be found to remain unchanged.

"This mode I regard as altogether erroneous. In fact there exists no such nerve as these names are used to signify. That which is taken for a nerve is, in truth, but a suite of communications between different nervous centres, situated at various distances from each other.

"These centres are the ganglions, scattered through the different regions of the body. They have all an independent and isolated action. Each is a particular magazine, sending a multitude of ramifications, to carry into the respective organs the irradiations of the centre whence they proceed.

"What anatomist," he continues, "has not been struck by differences among the nerves? Those of the brain are larger, whiter, more dense, less numerous, and offering few varieties; whilst extreme tenuity, great number, especially around the plexuses, grayish colour, peculiar softness

of tissue, frequently occurring varieties, are, on the other hand, the distinguishing characters of the nerves that issue from the ganglions. The only exceptions in either case are in the branches of communication between the cerebral nerves, and in a few of the twigs that unite the little nervous centres." Bichat thought it essential to realize these views in the descriptive anatomy. That commonly given is not calculated to convey an exact notion, either of the nervous centres, or of the nerves that emanate from them.

Comparative anatomy, and acephalic monstrosities among the mammalia and man, furnish incontrovertible proofs of the brain not being the origin of the nervous system at large. To compare the nervous systems of different tribes is a task attended with much difficulty; but very many of the inferior animals have nerves, although they have nothing that may be likened to a brain. Their nervous system, consequently, cannot have had the origin commonly assigned to it by authors.

There are also many anatomical descriptions, to be found in books, of acephalic monsters, of the more perfect animals, and of the human kind, whose nervous system, notwithstanding the absence of brain, was quite perfect. That nerves may exist without a brain is therefore established as a truth beyond the sphere of doubt.

Some writers, however, relying on the authority of Morgagni, Haller, and Sandifort, have maintained that the brains of acephali exist in the first instance, but that dropsy of the cavities destroys the parts, which, at birth, are found wanting, along with the membranes and bony covering.

But no one ever saw an acephalic child whose brain and skull exhibited traces of such destruction. The integuments of the upper part of the head, where the destructive process is principally supposed, are commonly entire and healthy. Neither has any one in these cases discovered the cicatrices of ulcers, nor traces of erosion, nor of simple absorption. The bones that compose the basis of the skull, when they exist in acephali, are smooth and round at the edges. The whole inferior part of the encephalic mass, too, and the optic, auditory, olfactory, and other nerves, occasionally occur in a perfectly sound and natural state. How did these nerves and tender cerebral parts resist the action of a fluid that dissolved or caused the absorption of membranes and firm bone? It must be allowed then, that the brain may be primitively wanting, just as may the legs or arms, and that the nervous apparatus of the body does not derive from the brain.

The first anatomical principle in regard to the nervous system therefore is, that *it is not an unit,*

but consists of many essentially different parts, which have their own individual origins, and are mutually in communication.

This principle Dr. Gall and I regard as essential to our physiological researches and deductions. No anatomist before us was ever so much interested in demonstrating its truth. We conceive that we have proved it satisfactorily in regard to the brain, as Bichat had done before us, to the nerves of the chest and belly.

In addition to our first anatomical principle, there are three subjects that require to be taken into consideration separately; these are,—1st, The mode in which the individual parts of the nervous system are formed; 2d, the order of developement of these parts; and, 3d, their reciprocal relations.

Dr. Gall and I, in our publications and anatomical demonstrations, have always spoken of the mode and order in which the cerebral parts are formed and developed; however, we never touched upon these points but in a general way, our attention being more especially given to the consideration of the plurality of the nervous apparatuses, of their communications, and of their mutual relations, the whole in harmony with our physiological and philosophical inquiries. Mr. Tiedemann, and, after him, Mr. Serres, have treated in a particular manner of the formation

and successional developement of the several parts composing the nervous system.

Of the Mode of Formation of the Nervous System.

I have no intention of entering into any discussion upon *Encephalogeny*. My researches have not been of extent sufficient to qualify me either to admit or to reject the opinions promulgated by M. Serres upon this subject. According to this gentleman, the spinal cord, the cerebellum, and the brain, are developed from the circumference towards the centre, and not, as anatomists had hitherto admitted, from the centre towards the circumference. He tells us, that there are many centres of formation, and that each apparatus is composed by several pieces, which are joined together, the extremities commencing, the middles terminating, the union. According to him, too *, the arteries exert a particular directing influence over the developement of the nervous system. The spinal cord, he conceives to be formed under the guidance of the intercostal, the cerebellum under that of the vertebral, and the brain under that of the carotid arteries.

The vessels of the spinal cord, he says, appear first, and the outline of this part is soonest

* Tom i. p. 568, et seq.

apparent. The common carotids appear next, and then the internal vessels of that name, which are distributed to the crura or legs of the brain, and to the bodies called quadrigeminal, and these are now evolved. The vertebral arteries reach the cranium last, and the cerebellum is the latest formed of all the nervous masses.

"The brain," he states, "is developed from before backwards, and the cerebellum from behind forwards, according to the direction of the blood-vessels. From this it comes that the callous body is evolved from behind forwards, as the arteria callosa gradually appears."

I intend in another place to cite M. Serres's notions upon the formation of some particular apparatuses. Here I only observe that he differs from M. Tiedemann upon a very principal point; whilst M. Serres proclaims a successive development from the circumference towards the centre, M. Tiedemann publishes the reverse of this as the truth. I also confess that a great number of M. Serres's opinions appear to me little probable. Dr. Baron * lately shewed the body of an hydrocephalic child to the Academy of Medicine in Paris, and proved that though the carotid arteries existed, the anterior cerebral lobes were wanting. M. Serres had made too hastily a contrary report upon this very case to

* Bulletin des Sciences Médicales, Juin, 1825, p. 175.

the Philomathic Society the day before Dr. Baron made the dissection.

In recognising the whole importance of encephalogeny, or the doctrine of cerebral formation, it still appears to me that its laws cannot be at variance with those that may be demonstrated in the brain when it has arrived at maturity of growth. I farther opine, that conclusions drawn from the structure of the adult brain, are to be preferred to such as are founded on it in its embryotic state. I shall, in more places than one, have occasion to refer to this argument, and especially when I come to treat of the anterior commissure and callous body, to the end that I may rectify the erroneous opinions promulgated by M. Tiedemann. My great and sole object is to know the structure of the brain, such as it may be demonstrated in harmony with physiology and pathology.

Of the general Form of the Nervous System.

The form of the nervous system, it may be conceived, varies according to the radiated, globular, or elongated configuration of the animal body, of which it is a constituent. It cannot be alike in the star-fish, worm, and caterpillar. (Pl. i. fig. 1.) Generally then, and even as its particular parts are concerned, the ner-

vous system exhibits the greatest varieties of form.

Its masses, too, occur aggregated, as in the skull, and spinal canal, or in the form of nerves properly so called, or collected into knots differing in form, size, consistency, and colour, and entitled ganglions. Nerves frequently emanate from distant and opposite sources to unite, anastomose, or twine together, and then to separate and run off in different directions. This is the particular arrangement to which the term *plexus* is applied. Ganglions and plexuses often form an intricate tissue together.

Of the Structure and Use of Ganglions.

Ganglions are bodies composed of the two nervous substances: the white or fibrous, and the gelatinous or pulpy, into which the first is plunged. The pulpy matter of the ganglions is commonly of a gray colour, of different degrees of intensity; sometimes, however, it has a yellowish, a reddish, or a whitish cast; it is easily distinguishable from the nervous filaments which it surrounds. The fibres of the white substance, the second element of the ganglions, anastomose repeatedly; they also cross each other frequently, sometimes in every direction, or in their course parallel with that of the nerve upon which the ganglion is formed. Ganglions

of this last kind are commonly oval-shaped, but those in which several nerves meet and inosculate, have for the most part very irregular forms.

Anatomists have always entertained very different opinions upon the uses of the ganglions. Some, with Willis, have ascribed to them the secretion of what they style vital spirits; others, with Vieussens, conceive them destined to separate and to strengthen the nervous fibres; many of the moderns again, Bichat, Reil, and others, think with Johnstone, that they serve to isolate from the influence of the brain the parts which receive their nerves from them. The latter authors divide the nervous systems into two parts: a cerebral and a ganglionary.

The theory of vital spirits is now forgotten. The ganglions are also proved to do more than merely separate or direct the nervous filaments, as Meckel the elder, Zinn, Scarpa, and others, have supposed. " A glance," says Bichat *, " enables us to discover the greatest differences among them, (the ganglions.) There is evidently as great a distinction between the ganglions and the nerves that issue from them, as there is between the cerebral nerves and the brain itself. There is difference of consistency and other outward qualities, and there is difference of properties. Were the nerves that come from the

* Anatomie Générale, T. I.

spinal cord merely unravelled in their passage through the ganglions, this would be but a difference of form, not of nature, and their properties, therefore, would remain the same. Why has not nature placed ganglions on the nerves of the limbs as on those of internal parts? If there be only a resolution of nerves into finer filaments in ganglions, why is there no constant proportion between the fibres that enter on one side, and those that issue from the other? Did the nerve that penetrates the superior cervical ganglion from above expand in its interior, and having reunited its filaments form the cord that issues from below, it ought evidently to be of precisely the same size at its exit as at its entrance. Such a relation, indeed, between the nerves of the opposite extremities of ganglions, ought to be quite general. But a very cursory examination shews that a contrary disposition almost invariably obtains. The size of the ganglions should be relative to that of the nerves, whose expanded fibres are said to compose them Why then are the intercostal ganglions so small, and the trunks which unite, or rather, to use the common phrase, originate, and then leave them so large? And why, on the contrary, is the superior cervical ganglion so voluminous, and its nervous branches so minute? How can the frequent interruptions among the ganglions in the human kind, which in a host of animals are quite regular, be explained, if the nervous filaments which enter

be continuous with those which issue from them? How comes it that the ganglions and their nerves bear no exact proportion to the cerebral nerves, if the latter give them birth or expand in them? Why, in fine, has not the pain, that is transmitted by both kinds of nerves, the same character?" Sœmmerring has made reflections very similar to these of Bichat.

Notwithstanding all this, the opinion in regard to the use of the ganglions, which Johnstone, Bichat, and Reil entertained, and which others have adopted from them, is by no means exact. They do not interrupt the reciprocal influence of the brain and nerves of the spinal cord, nor of the brain and viscera of the chest and belly, either in the healthy or pathological state of the body. They most certainly do not prevent impressions made on parts supplied with nerves from them, or diseased sensations of the viscera from being felt. On the contrary, the ganglions would appear essential to the structure of nerves of sensation. They, however, abstract the parts they furnish with nervous energy, from the influence of the will. They also originate nervous fibres; and serve, farther, as points of communication between different nerves. Lastly, as the existence of a nervous fluid is not impossible, nay, as in all likelihood such a fluid does exist, the ganglions may probably aid in its secretion or evolution, and modify its circulation or distribution.

Section II.

Division of the Masses composing the Nervous System.

We have already seen, among the general considerations, that the nervous system is not a simple unit, but an aggregation of parts, that originate and may exist separately, but which are in intimate communication, as was required on account of the influence their functions exert mutually. The functions of the abdominal viscera, for instance, act upon those of the brain, and those of the brain influence digestion, circulation, the secretion of bile, &c. The nervous system, therefore, cannot be compared to a net, as is sometimes done, if, by this, similarity of nature in its constituent parts be implied. On the contrary, as differences are evident, divisions become indispensable.

But the task of determining the instruments specially dedicated to particular functions, is one of great difficulty. The ordinary division of the nervous masses is indisputably defective. A true one can only rest on the nature of the functions performed. These functions are naturally separated into two grand classes: vegetative, or organic functions, and phrenic, or functions having

place with consciousness. The nervous masses belonging to the first of these are, in common language, the great sympathetic nerve, and the ganglions and plexuses of the thorax and abdomen. Bichat has divided them into a multitude of apparatuses, individually necessary to the offices of the particular viscera. This division is, in my apprehension, founded in nature. I regard the nervous masses of vegetative life as independent of those of phrenic life, in as far as their existence is concerned. I also incline to admit as many dif ferent kinds of nerves as different vegetative functions; I farther recognise their communications among themselves, and with the masses of the phrenic functions.

The nervous masses of vegetative life are very simple in the lower tribes of beings; they are more numerous as we mount in the scale, and as the functions of vegetative life become complicated. Their general arrangement, as was to be expected, varies according to the form and disposition of the viscera in species and individuals. If visceral functions, locomotion, and manifestations of sensibility be united, it is also conceivable that to separate the peculiar nerves of these dissimilar operations from each other, would be next to impossible. This consideration shews why some anatomists have compared the nerves of the caterpillar and worm to the great sympathetic; whilst others have likened them to the

intervertebral ganglions, or to the spinal cord itself.

In the vertebral classes of animals, and especially in the mammalia, the nervous masses are distinctly separated, first, into those of vegetative life, and, second, into those of phrenic functions. Each of these may farther be subdivided into two parts: the first into nerves of viscera, or, as M. de Blainville * expresses himself, into a *visceral* portion, and into nerves of communication; that is, an apparatus which establishes sympathy among the visceral nerves mutually, and between these and the nervous masses of the external senses, and of the affective and intellectual functions.

The second, or nervous masses of phrenic life, again, are commonly divided into the brain, properly so called, the cerebellum, medulla oblongata, and spinal cord, together with the nerves of these four parts.

M. de Blainville ranges the nervous masses of phrenic life under two titles: the one he styles *Central*, the other *Ganglionary*. "The first, or central," says he †, "is susceptible of three degrees of development; is always situated above the intestinal canal, begins with the œsophagus or pharynx, and is prolonged, more or less

* Bulletin des Sciences par la Société Philomatique de Paris, 1821, Mars et Avril.

† Op. cit. p. 44.

backwardly, so as to correspond to a greater or smaller number of rings of the body when they exist.

"The second, or ganglionary, consists of a very variable number of pairs of ganglions, disposed in a slightly different manner on each side of the first.

"The central portion is always composed of two similar halves, situated, the one to the right, the other to the left, and more or less intimately united, or drawn together by means of the peculiar apparatus, styled commissure. It is divided into two *rigorously similar* portions: a *vertebral* and a *cephalic*, included, as their titles imply, the one in the vertebral canal, the other in the cranium. Both contain gray and white substance, and longitudinal and transverse commissures.

"The cephalic portion consists, 1st, of an inferior bundle called pyramidal, which passes under the annular protuberance, continues long distinct from the cerebral peduncles, and runs to terminate in the anterior, or olfactory lobe, of the brain. 2d. Of a superior bundle, which continues, in the first place, under the name of prolongation of the quadrigeminal bodies, to the cerebellum, and running on the outer sides of the internal geniculated bodies, is lost on the hemispheres; and, in the second, of a deep bundle, which may be followed to the mammil-

lary bodies, and from thence into the optic thalami. The bundles named peduncles of the pineal gland, which are expended on the optic thalamus, are also to be regarded as belonging to this cephalic portion."

The same author subdivides his second or ganglionary portion into ganglions without, and ganglions with, external apparatus. Among the former he reckons the olfactory masses, the hemispheres properly so called, the quadrigeminal bodies, and the cerebellum. The olfactory nerve, according to him, is a cerebral mass, in which his inferior central bundle terminates. The hemispheres, he conceives, form another ganglion, having no external apparatus, but one transverse, (the callous body,) and two longitudinal commissures (the peduncles of the brain and the fornix). It is to this ganglion that the convolutions belong. He farther regards the striated bodies as appertaining to the convolutions, but remarks that, for certain, their fibres do not originate there to go to the hemispheres. The quadrigeminal bodies are the third, and the cerebellum the fourth, ganglion, without external apparatus.

The title, *visceral part of the nervous system,* appears to me well chosen, but I do not think that the division into central and ganglionary parts, or the other subdivisions proposed, deserve the same approval.

In the first place, I cannot see that they are

based on anatomical observation; I do not believe, for instance, that M. de Blainville can demonstrate the continuation of the inferior bundle, or pyramidal body, into the olfactory nerve, nor that he can trace what he calls the deep bundle (*faisceau profond*) of his central portion into the mammillary bodies. Neither do I think that his divisions and subdivisions of the nervous mass pertaining to phrenic life, are consistent with physiological facts; but this in anatomical classification is quite essential: it is even acknowledged by M. de Blainville himself as its basis. "We ought," says he *, "to consider the nervous system as subdivided into as many parts as there are grand functions performed by the animal body."

According to the ideas of M. Desmoulins, the parts which constitute the complete cerebro-spinal system of mammalia, are—1st, the spinal cord; 2d, the cerebellum, which is itself composed of three parts; 3d, the optic lobes, or quadrigeminal bodies; 4th, the lobes of the brain; 5th, the olfactory lobes. These five parts are admitted by M. Desmoulins not to be always complete in the other classes of vertebral animals, and also to be wanting, individually, without detriment to the rest. The sturgeon, lamprey, frog, and some other creatures, have, he says, no cerebellum; the skate and shark no cerebral lobes; many

* Op. cit. p. 40.

bony fishes no olfactory lobes; in short, he concludes, that generally speaking, the notion concerning the unity of the nervous system is a chimera.

In opposition to M. Demoulins's views, Dr. Bailly has maintained that every vertebra, or every segment, through the whole length of the animal body, contains the same nervous elements; that belonging to each of the vertebræ of the head and spine, there are nerves of sensation, of motion, of digestion, and of an intellectual system, charged with the task of appreciating the impressions communicated by the others, and of producing determinations.

In my apprehension, the cerebro-spinal system is not a simple unit, but a compound of many distinct apparatuses, each of which has particular functions, which, being taken together, constitute phrenic life. The several instruments are formed after a general plan, but the physical qualities, as the density, form, size, and colour, of all, individually, differ not only in the classes and in the species, but also in the members composing each kind; the number of particular organs is likewise greater or smaller in the classes and species, according to the amount of the primary functions, or faculties; lastly, each of the apparatuses is simple, or it is compound.

No one, however, can be said to be perfectly simple; each is, at least, double, or one of a pair.

The organs of motion and of touch are evidently multiplied.

It is essential, in dividing and subdividing the parts of which the cerebro-spinal system is composed, to keep in harmony with physiology and pathology, and to distinguish between what is common to all, and what is peculiar to each of them. The first grand division must embrace the instruments of motion, and of the five external senses; the second comprise the organs of the affective and intellectual functions.

I think they do wrong who confound the spinal cord with the cerebral masses, and designate both by a common title, such as *encephalon* or *brain*. It is long since Dr. Gall and I pointed out this error, but it is still very generally sanctioned, by the French Academy of Sciences, for instance, so late as 1820, its prize having been accorded to the memoir of M. Serres upon the following title.—"Donner une description comparée du cerveau dans les quatre classes des animaux vertebrés, et particulièrement dans ceux des reptiles et des poissons, cherchant à determiner l'analogie des différentes parties de cet organe, ou marquant soigneusement les changes des formes et des proportions éprouvées, et suivant aussi profondement que possible les racines des nerfs cerebreaux." Here the brain and its nerves only are evidently spoken of. M. Serres, however, deemed it proper to consider the nervous mass of the spine as

well as of the cranium, and he has designated these two systems by the same name, without any objection being made by the Academy to this arrangement.

Let us turn to the facts that prove the brain and the spinal cord to be perfectly distinct and independent of each other. These facts are anatomical, physiological, and pathological. I here assume as an established point, that the functions of the spinal cord differ entirely from those of the brain. The development and demonstration of this truth belong to physiology. I have, accordingly, examined it particularly in my work on Phrenology. Physiological experiments and pathological facts tend equally to show that the brain and spinal cord are masses possessed of distinct functions that cannot be confounded. This volume being destined solely to the discussion of anatomical views, I shall, at present, confine myself to such evidence as anatomy affords of the mutual independence of each of the nervous masses mentioned.

And first—all that has been said, in a general way, upon the origin of the nerves, and their existence, independently of the brain, applies particularly in the case of the spinal cord. The spinal cord sometimes exists in part, sometimes entirely, when the brain is altogether wanting. If, to this, it be objected that the brain had been removed by absorption, the answer I have given

to the same proposition, in reference to the nerves in general, must be repeated here. There is, also, one, and but one, case on record, in which the brain existed, without the spinal cord*. It occurred in a child whose head or heads are preserved in the Hunterian Museum, in London; this child was born with one skull placed vertically upon another. Each of these contained a brain invested with its usual membranes; the dura mater of each brain adhered closely to that of the other, and both were supplied by blood-vessels issuing from common trunks. Parts, consequently, as the brain and spinal cord that exist, or not, independently of each other, cannot constitute one and the same apparatus.

2. The nervous masses of the spinal canal and cranium bear no regular proportion to each other. Man, with his voluminous brain, has a smaller spinal cord than the ox or horse, whose brain is so much less. Bartholin in former times, and Sœmmerring in our own days, made this remark; nevertheless, they both continued to speak of the spinal cord as a process or continuation of the brain.

3. The spinal cord is well known not to decrease in size as it descends in the vertebral canal, and as it sends off nerves. Its volume is even augmented, where its nerves are largest and

* See Philosoph. Trans. for 1790, March 25th, and for 1798, Dec. 13th.

most numerous; this is obvious, especially towards its sacral end, as may be seen by turning to Pl. i. fig. 2, where this part of the spinal cord of a fowl is represented; and yet the spinal cord is commonly considered as a prolongation of the white substance of the brain and cerebellum!

4. The direction of its nerves, especially in the mammalia, proves to a certainty, that the spinal cord is not a continuation of the nervous mass of the cranium. Every pair of spinal nerves is made up by several bundles: (Pl. i. fig. 3; a part of the spinal cord of a calf;) some of these issue from below, and run upwardly; others come from above, and proceed down and outwardly. Now it would be absurd to suppose that these bundles were continued, or derived either from the lower or upper extremity of the spinal cord. They undoubtedly originate at the place whence they issue individually.

In regard to the fifth, sixth, seventh, and other pairs of nerves, styled cerebral (Pl. vi. fig. 1), their direction also shows that they do not come either from the brain or cerebellum. Santorini, when speaking of the course of the fifth pair, remarks, that after descending from the brain, it turns back and runs upwards; and he adds—"if it do not probably come from below, entirely like the accessory nerve."

The proofs, confirmatory of the mutual independence of the spinal cord and hemispheres of

the brain and cerebellum, serve also to demonstrate the propriety of separating the nerves, styled cerebral, from the brain itself. The evidence in this, as in the other case, is anatomical, physiological, and pathological. For the reasons already given, I here rest on anatomical testimonies alone; for information on the others, I refer to my physiological and pathological treatises*.

To proceed, then, we see monsters, occasionally, born without any of the proper cerebral masses, but with olfactory, optic, and acoustic nerves, either severally or altogether perfect; and on the contrary, these nerves, individually, or generally, have been found in a state of atrophy, whilst the brain was sound and well developed in all its parts. There is no proportion, whatever, between the cranial nerves and the true cerebral mass. Many animals have them much larger in proportion to their brain than man.

I repeat, therefore, that I divide and subdivide the nervous masses according to their offices: first, into nerves of vegetative functions; secondly, of external sense, and locomotion; lastly, of affective and intellectual operations: these last inhere in parts, which I style truly cerebral, superadded to the nerves of the senses.

We shall, afterwards, see that the masses belonging to the last-named class of functions require

* Phrenology; or, the Doctrine of the Mind; Lond. 1825. Observations on Insanity; Lond. 1816.

subdividing into instruments of particular functions, after the manner of the external senses.

This principle of the plurality of the nervous apparatuses is the basis of these anatomical considerations, and is indispensable to the physiological researches in which Dr. Gall and I have so long been engaged. It has been, and is still, contested, and at the same time it is brought forward as new. A reference, however, to the date and matter of our publications, will assign it to those who can claim it by right. The general idea of a plurality of organs, indeed, must be allowed to be very ancient, and not the discovery of any modern author; before Dr. Gall appeared, however, none of the cerebral functions had been specified, and before our combined investigations were made public, the structure of no special apparatus had been demonstrated; for the parts of the encephalon that bear distinguishing titles, do not, by any means, constitute particular organs. The special determination, as well anatomical as physiological, consequently, belongs to Dr. Gall and myself.

Section III.

Of the Nervous Masses of Voluntary Motion and of the External Senses.

These masses include the spinal cord, with its nerves, and the nerves of the head, distinguished by the title, *cerebral nerves.* They may, therefore, be divided and spoken of as *spinal* or *vertebral,* and as *cranial.* The former, principally contained in the canal of the vertebral column, are more considerable in size, and are entirely destined to the functions of feeling and voluntary motion; the latter are less voluminous, but besides nerves of voluntary motion and of feeling, they include nerves of taste, hearing, sight, and smell.

Anatomists have, at all times, separated the nerves of four of the senses, to wit—smell, taste, sight, and hearing, from those appropriated to feeling; they have also regarded the third, fourth, and sixth pairs of nerves as especially destined to motion; but they have confounded all the other trunks of the medulla oblongata and spinal cord, and supposed the whole to pertain to feeling.

It is long since I maintained the necessity of subdividing these nerves, and of admitting separate fibres for the functions of touch and

of motion. My opinion was founded on facts, and reasonings anatomical, physiological, and pathological. It was long ago remarked that feeling and voluntary motion were not always impaired or annihilated simultaneously; sometimes the one, sometimes the other of these functions was seen to be totally lost, whilst the other remained unimpaired. The conclusion then followed, and it had already been seized by Erasistratus of Alexandria, that there were nerves of motion, and nerves of feeling. Pathological facts, therefore, first fixed the attention of physicians on this point, as they also gave the first idea of a decussation of nervous fibres in the brain, and of the peculiar structure of the convolutions.

To the above, some have replied that the admission of two sorts of nerves to explain the isolated lesion, whether of voluntary motion or of feeling, was unnecessary; the loss of motion, they say, is consequent on a minor degree of cerebral affection, the destruction of feeling on disease of a graver and more extensive description.

This objection is purely speculative, and is totally unsupported by experience. To make it even plausible, it should surely be capable of standing the test of physiological proofs in the healthy state, that is to say, sensibility and volition should be shown to be mere degrees of the same power, volition being the lower of the two; but observation is very far from confirming such an opinion.

Physiology, and analogy, in reference to the other senses, appear to determine feeling as a function entirely distinct from voluntary motion, and to prove each of these functions as manifested by the medium of a special organ or nerve. The functions of touch are active and passive, like those of the other external senses. The muscles are called into action, would the internal faculties employ any of the senses to cognize impressions from without. They aid touch in feeling, as they assist sight in looking, hearing in listening, and the olfactory nerves in smelling. The nerves of voluntary motion, *i. e.*, of its organs, the muscles, cannot propagate impressions of touch, nor the nerves of the skin those of motion. The impressions propagated by the nerves of motion come from within, as those transmitted by the nerves of feeling are derived from without. The muscles, alone, produce sensations of fatigue or weariness, and these have no relation to the nerves of feeling: we may be excessively fatigued, and at the same time, have the sense of touch extremely vigorous.

Physiological and pathological facts being strikingly and universally favourable to the idea of distinct nerves of feeling and motion, and four of the senses being evidently provided with peculiar nervous apparatuses, I have always maintained the probability of the same law obtaining, in regard to the fifth, and even invited anatomists to use their endeavours to verify the point, and to de-

monstrate the muscular as distinct from the cuticular nerves.

To the above notion, it has been objected, that the nerves of feeling and of motion issue together from the spinal cord, and, as a consequence of this, that the nature of every fibre, of the same pair, must be essentially the same. To this I always answered that the objection is neither valid on the strength of the fact, nor on that of the inference from it. For the spinal pairs are composed of two roots, the one dorsal, the other abdominal; and further, each root is, itself, composed of many bundles. I also stated that this structure was less conspicuous in the fifth cranial nerve than in the spinal pairs; but that, nevertheless, the difference of its bundles, and their dissimilar functions, were recognised. One, all allow, is appropriated to taste, whilst the rest belong to sensation in general. In conformity with the above view, the glossopharyngeal has always appeared to me destined to the third sort of the lingual functions, that is, to general feeling.

The above ideas were published in my English work, "The Physiognomical System *," in 1815; and in 1818, in my French book, entitled, "Phrénologie †." In all the courses of lectures I have delivered since these works issued from the press, I have broached similar ideas, and encouraged those of my auditors, whom opportunity

* First and Second Edition, p. 23. † Op. cit. p. 236.

favoured, to enter on the inquiry, and to endeavour to trace the nervous fibres from their peripheral expansions to their origin in the spinal cord.

The subject has, indeed, been advanced by the labours of Messrs. C. Bell and Magendie. Mr. Bell has recognised a difference between the nerves of sensation in general and those of respiration *. He admits, in the first instance, that every apparatus operating a single function, is provided with but one nerve; that parts which receive two nerves, whose origins are different, perform two functions; and that organs, whose nerves are derived from several sources, effect various, and not merely stronger, functions of one specific kind. He regards as respiratory nerves the pneumogastric, with its vocal branch; the glossopharyngeal; the accessory of Willis; the facial; the hypoglossal, and the diaphragmatic (the phrenic).

Mr. Bell has further established a difference in function between the facial nerve, (portio dura of the seventh pair,) and the branches of the fifth pair. He has proved by his experiments, that the facial gives no impression of pain when it is cut, but that the effect of the operation is to abstract the parts upon which it is ramified from

* On the Nerves; giving an Account of some Experiments on their Structure and Functions. Read before the Royal Society of London, July 12, 1820.

the influence of the respiratory motions. Lesions, on the contrary, of the fifth pair, produce pain, and the parts it supplies become insensible, when its branches are cut across. He still further cites cases, in which sensibility remained unimpaired, although the side of the face was completely paralyzed in its movements.

Mr. Bell has given his attention more particularly to the influence exerted by the facial nerve on respiration, and by the function of respiration on parts that receive branches from this source. The facial he styles, in particular, *nerve of expression.* Being a nerve of motion, however, it may, independently of any additional consideration, be entitled a nerve of expression. That it may be influenced by respiration, no one will probably deny, but it may also unquestionably act independently of this function. Mr. Bell, indeed, has not in this instance adhered rigorously to his principle recognised in theory, and mentioned above, *viz.*, that no nerve performs two functions—the facial, on his own data, can only be a nerve of one kind of function.

I chanced very lately to see a case where the voluntary motion of the right side of the face was lost, whilst its sensibility remained; both feeling and motion on the left side were intact; the movements of the tongue were also natural; but if the person attempted to spit, the saliva was

always thrown to the right by the action of the left and healthy half of the cheeks and lips.

M. Serres gives the case of a young man, who was constitutionally epileptic, and troubled with a slight ophthalmy in the right eye. The latter affection increased gradually, the cornea became opaque, the sight decayed more and more, and was, in fine, entirely destroyed; the other organs of sense and motion on the same side were successively paralyzed; the eye, eye-lid, nostril, and half of the tongue, lost their powers, whilst on the left they remained in a state of perfect integrity. This patient died. On dissection, there was found, first, an organic change of the ganglion of the fifth pair; it was enlarged, of a yellow colour, and vascular below; second, a conversion of the nerve itself, at its insertion into the annular protuberance, into a yellow gelatinous-looking matter, similar to the ganglion, and penetrating, in little processes, the substance of the protuberances in the direction of the nervous insertions. The muscular branches of the nerve, however, were found healthy on the otherwise affected side; the process of mastication, therefore, had never been injured.

The difference in the functions of the facial nerve and fifth pair, affords a new proof of the distinction between nerves of feeling and nerves of motion.

M. Magendie * found that sensibility was destroyed when the dorsal roots of the spinal nerves were cut through, and that motion suffered when the abdominal origins were the subjects of his experiments. He also observed that the abdominal side of the spinal cord was less sensible to pricking or cutting than the dorsal; but that the introduction of a probe along the axis of the part did not seem to have any influence either upon motion or sensation. The case of a man, who died in his sixty-sixth year at Charenton, seems to corroborate these ideas. During the last seven years of his life his organs of motion had been paralyzed, but those of sensation remained uninjured; his intellectual faculties were almost annihilated, and his excretions were all involuntary. Thus reduced, he died. On opening the body, the pyramidal and olivary bodies were found pulpy, and of a dirty gray colour. The same change was observed along nearly the whole of the anterior surface of the spinal cord, and penetrating through almost the whole thickness of the fibrous bundles that compose it. The abdominal roots of the spinal nerves were still visible, but their consistence was much diminished. The dorsal surface of the cord, on the contrary, and its investing membranes, were in a healthy condition.

* Journal de Physiologie Expérimentale et Pathologique, tom. iii.

I am, however, rather inclined to question the accuracy of the report in reference to the brain and cerebellum, when they are stated to have been in a natural state; for I observe that the skull was eburneous, and three times thicker than common. Such changes of the cranium are, I believe, constantly accompanied by alterations in the encephalic masses.

M. Magendie also mentions a singular case, observed by M. Rullier, of a man who died at the age of forty-four. Up to his last hour this person possessed great moral energies, strong generative powers, free motion of his lower limbs, and perfect sensation in his upper extremities. The arms, however, were rigid, their muscles being permanently contracted, and often painful. They were rotated inwards, and pressed to the sides of the body, from which they could not be separated, but with some considerable effort. The fore-arms were in a state of uneasy pronation, the hands flexed, and all the fingers bent. On dissecting the body after death, " the spinal cord, examined with care, appeared in its natural state, from its upper end as low down as the exit of the fourth pair of cervical nerves. The dorsal surface of its two lower thirds was also healthy, but between the portions named, and through a space corresponding to the branching of eight or nine pairs of nerves,

(six or seven inches in extent,) there was a very decided alteration. The spinal cord was there so extremely soft and diffluent, that the sheath formed by the dura mater seemed filled with a true fluid, which, indeed, flowed upwards or downwards, as the body was inclined. A puncture being made through the sheath, a considerable quantity of fluid instantly escaped."

The last passage of this report, in reference to the puncture of the dura mater, does not seem to me very exact; because in a preceding sentence it is stated, that "below the part of the arachnoid, which adhered to the spinal cord, its proper membrane seemed charged with a great number of vessels, both arteries and veins, all loaded with blood." This description leads me to conceive that the dura mater was slit lengthwise, and separated from the arachnoid and proper investing membrane of the spinal cord. If this were not so, the dura mater must then have adhered to the two inner membranes, and the puncture, consequently, could not have been confined to the first alone. I am confirmed in this opinion by what M. Magendie says, when he adds, that the man had probably lost a good third of the nervous matter of the spinal cord, that the communication between its cervical and dorsal parts was, so to say, maintained *by the membrane only*; for there seemed to remain no more of its entire thickness than a layer of white

substance, scarcely two lines broad, and probably altered in its structure.

The state of the nervous pairs, corresponding to the part of the spinal cord that was destroyed, ought also, in my opinion, to have been mentioned. Information on the structure of the remaining thin layer of nervous substance would likewise have been interesting; was it composed of longitudinal fibres, serving as a means of communication between the upper and lower portions of the spinal cord? Is it at all probable, that this office was performed by the *sheath* as stated? If it was, the *sheath*, most certainly, was neither the arachnoid nor the dura mater. The nevrilema, that envelopes the pulpy nervous substance immediately, could alone execute such an office.

M. Boulay, jun., veterinary surgeon at Paris, relates the case of a horse, whose hind legs were completely paralyzed, whilst their sensibility was extreme. On opening his body, the whole of the lower part of the spinal cord was found soft and diffluent. There were no traces of change in the superior portion. The nervous substance of the lumbar and sacral pairs of nerves was but little consistent, and their sheaths were red and inflamed.

The distinction of the nervous roots into dorsal and abdominal, accords with the two sorts of function performed by the spinal mass. This

subject, however, still requires elucidation; for M. Magendie remarks, that "when the posterior roots, covered even with their sheaths, are irritated, signs of extreme suffering are manifested; and, what is particularly deserving of notice, contractions of those muscles that receive nerves from below the place so irritated are excited; these contractions, too, only occur on the side of the body the nervous fibres of which are pricked." According to the observations of the same author, the abdominal surface of the spinal cord is not altogether insensible when irritated. The communication between the spinal cord and the nerves of the vegetative functions is also known to be established by means of fibres, which communicate directly with the abdominal roots of the spinal nerves; nevertheless, the will has no influence over the functions of the viscera. Moreover, the fibres of the dorsal roots are evidently larger than those of the abdominal; both are in proportion to the volume of the parts to which they are distributed, and both send off branches that run into muscles. It is improbable, therefore, that the dorsal roots are solely destined to general sensation. Neither does it seem to me at all likely, that the spinal cord and its nerves are mere conductors of sensation, and of volition in reference to motion. I rather conceive that they aid in maintaining the powers of those parts to which they are distributed; for in-

stance, that the muscles, or instruments of motion, acquire their power, in part, through the influence of their nerves, whilst the will to make the muscles act resides in the brain. Thus I do not believe that the only office of the spinal cord, with its nervous roots, is to establish a communication between external impressions and the brain, and between the brain and the instruments of motion—the muscles. To me it seems probable, that a very small part of the spinal cord suffices for these purposes; the particular portion, or organ, however, cannot, in the present state of our knowledge, be specified. The experiments of M. Magendie prove the abdominal roots to include the conductors of volition; but as each of these is composed of two halves, the one superior, the other inferior, and, in man, of two distinct cords, it would be interesting to repeat and to extend the experiments, and by cutting the halves separately, to ascertain whether both propagate the dictates of the will; or if this task is limited to one, to that, namely, which does not communicate with the intercostal nerves. The ganglions of the intercostal nerves, as well as those of the dorsal roots of the spinal cord, may possibly prevent the will influencing the functions of the parts, to which these nerves are distributed.

The set of experiments instituted by Dr. Bellingeri, and detailed in a Memoir read before the

Royal Academy of Sciences at Turin, in February, 1824, do not tend to throw any new light on this interesting subject. They confirm the general idea upon the presence of separate nerves of sensation and of motion in the spinal cord; but they, farther, accord motion to the nerves that issue from the dorsal roots. Dr. Bellingeri says, his experiments prove, 1st, that the *posterior* roots of the lumbar and sacral nerves produce the motions of extension in the lower extremities; 2nd, that the posterior roots alone preside over sensation; 3rd, that the anterior roots produce the motions of flexion in the sacral extremities, and do not aid in perceiving external impressions; 4th, that the posterior bundles of the spinal cord preside over the motions of extension of the inferior extremities, and have no connexion with perceptions of touch; 5th, that the white substance of the spinal cord, and the nervous fibres that arise from it, are appropriated to motion; and, 6thly, that the gray substance of the cord and the nervous fibres that spring from it, belong to sensation.

I have copied these statements from the 'Revue Encyclopedique,' vol. xxi. p. 723. The 'Bulletin des Sciences Médicales,' for June, 1825, also records these experiments, the inferences from which are in opposition to those deduced by M. Magendie from his own.

I do not think with Dr. Bellingeri, that the

vertebral nerves can be divided into those which come from the white, and those which issue from the gray, substance of the spinal cord; because, on examining the structure of this part and its nerves, I find that the origins of the latter invariably present the same appearance; they are universally implanted, as it were, into the gray substance of the cord.

From all I have said, it must be evident that I do not doubt the presence of two distinct species of nerves among those that issue from the spinal cord in particular, one propagating impressions from without, the other conveying the dictates of volition, in regard to motion, from within. This subject, however, is obviously involved in much obscurity, and will require ulterior and farther investigation to be rendered clear.

Let us now examine the structure of the nervous mass of the spine, known under the title of spinal cord, or spinal marrow.

CHAPTER I.

Of the Nervous Mass of the Vertebral Column.

The spinal cord is found in all vertebral animals, whilst in the avertebralia, such as worms, insects, the crustacea, and mollusca, the nerves form masses, which are separate and distinct in

the ratio of their functions. The digestive powers of the avertebralia commonly predominate over those of general sensibility ; and the same ganglions that supply the viscera with nerves, also supply the muscles. In the vertebralia, on the contrary, where sensation and motion play principal parts, there are particular nervous masses destined to each kind of function.

The spinal cord having always the same functions, may be conveniently compared in the four classes of vertebral animals. In all, its structure is essentially the same ; modifications only are to be observed.

General Considerations on the Spinal Cord of Man and Animals.

The nervous mass of the spine is composed of two similar halves, one on each side of the mesial plane of the body. They are parted to a certain depth by two longitudinal clefts, the one, of course, on the dorsal, (pl. i. fig. 5,) the other on the abdominal surface, (pl. i. fig. 4, *s*—*s*), and united between these fissures by a commissure, or apparatus of union, (pl. i. fig. 6 and 7. 9—9). This commissure is pierced in its interior by a canal, which is more or less distinct in different animals, (pl. i. fig. 8 and 9,) and is especially visible during the earliest periods of life.

The canal of the spinal cord has given rise to

muc hdiscussion, and nothing certain is even now concluded in regard to it, neither as to the space it occupies, nor to the mode of its formation. Before explaining my own views upon this point, I shall quote a passage, published in the first volume of our large work on the "Anatomy and Physiology of the Brain and Nervous System."

"M. Demangeon and Messrs. Devilliers, uncle and nephew, afforded us the opportunity of examining a case of *Spina bifida*, conjoined with considerable hydrocephalus. From the second to the fourth lumbar vertebra, the spinous processes of which were wanting, there extended a membraneous pouch about two inches in diameter. During the eighteen days which the child survived its birth, a great quantity of fluid exuded continually from this pouch. Having cut away some of the other vertebræ, we observed no swelling of the dura mater, neither did any fluid escape when we slit open this membrane lengthwise. It was only between the arachnoid and the proper vascular coat, that a small quantity had accumulated, and it communicated with the pouch.

"The spinal cord was of its usual form. We shook the head, and turned it in every direction, but could perceive no communication between the water collected in the ventricles of the cerebral hemispheres and the spinal cord or its membranes.

"To learn, positively, whether or not any communication did exist between the pouch and

interior of the spinal cord, we cut this across in the neck; it appeared in the usual state: on blowing, however, through a pipe upon the transverse cut, each half of the cord presented an opening, about the magnitude of a middle-sized goose-quill. The two canals were separated by the commissure. We could not inflate the spinal cord through its entire length at once. We could only effect this partially. Downwards, the air penetrated freely for three inches, but there the canals were no farther pervious, so that no communication existed between them and the pouch. Neither could we perceive that there was any fluid in the canals. The pouch, itself, was formed partly by the dura mater and tunica arachnoides. Its superior edge touched the lower extremity of the spinal cord. Although we had blown into the two halves of the spinal marrow in so easy and uniform a manner, we still could not determine whether the canals were to be considered as an effect of disease or not. We, therefore, examined the spines of children at the period of birth, of others somewhat older, and of adults; in all we discovered a corresponding organization. We, however, found that the canals did not expand before the blow-pipe so readily in children somewhat advanced, and in adults, as they did in subjects in the earliest infancy; we, therefore, to show the fact, prefer the bodies of newly-born children. In other respects, precisely similar openings on

each side are to be observed in all; the interior surfaces too, being always smooth. If the blowing into the canals be continued from below until as many as six or eight lines are opened, and only five or six lines are cut off in succession, so that the opening may be always maintained, the canals may be followed into the medulla oblongata, the tuber annulare, under the corpora quadrigemina, through the crura cerebri, and even on to the supposed optic thalami and the commencement of the corpora striata. Although no opening be observable into the fourth ventricle, nor into the aqueduct of Sylvius, nor into any other of the cerebral cavities, this structure, nevertheless, would incline us to admit the possibility of a fluid being secreted by the canals, and producing a true dropsy of one or both cavities of the spinal cord.

"Each half of the spinal cord then may be considered as a membrane doubled on itself, along the middle line of which the gray substance, although without apparent division, may, by a slight blast, be separated, so as to form the sides of a canal.

"No violent separation can here be supposed; for, in the first place, it is effected with perfect ease, whilst in other situations, and even where the gray substance is much softer, no disjunction can be operated without the greatest difficulty. Secondly, where a separation of parts is the consequence of violence, the edges are ragged and uneven; whilst in the case cited, the surfaces are

continuous and smooth. Thirdly, the openings in the situations mentioned, are always found in the same places, are perfectly equal, being sometimes quite round, sometimes oval-shaped, sometimes slightly angular, and running now horizontally, then vertically, obliquely, or in a semicircular direction, according as the curves of the medulla oblongata, of the pons Varolii, of the crura cerebri, of the optic thalami, or the parts that surround the canal determine. If the air be propelled too forcibly, the canal will burst where the gray substance is the most slightly covered by nerves, as at the places where the nerves issue, although the tearing off of these does not, of itself, give any outlet to the air."

Since the above was written, I have seen reason to change my opinion, and I now consider the canals to be mere effects of the blowing. I have produced them in birds and fishes as well as in man. They are not, however, I must here observe, to be confounded with the true canal of the spinal cord—the canal that exists in the interior of the commissure or apparatus of union. This is quite uniform, and is occasionally the seat of disease, getting filled with serum. It is more or less distinct in animals of the inferior classes, and in the embryos of those of superior tribes. In the human fœtus, it is commonly visible during the first four or five months from conception. After this date it is generally, though not inva-

riably, obliterated. This explains how its existence has been at one time admitted, at another denied, and how, in extraordinary cases, it has even been found in advanced old age, as Charles Etienne, Columbus, Morgagni, Senac, Portal, and other authors have observed. The canal of the spinal cord appears to be analogous to the aqueduct of Sylvius.

M. Serres has said that the spinal marrow in young embryos consists of two cords, which unite first in front and compose a gutter, but which coming together, speedily get blended behind. The interior of the spinal marrow is then hollow, and forms a long canal, which is gradually filled up by the deposition of successive layers of gray substance secreted by the pia mater, which has insinuated itself into the canal.

This account does not appear to me correct and conformable to nature. I allow that the two cords unite at the bottoms of the clefts, but I likewise maintain that each contains gray matter in its interior, in the direction of the two nervous roots that are implanted. But were the spinal mass developed, and its canal obliterated, as M. Serres would have us believe, by the deposition of gray substance in successive layers, this process ought, evidently, to go on in the interior of each of the cords composing it, and not in the canal between the two similar halves.

The corresponding parts of each half of the

spinal cord are voluminous in the ratio of their implanted nerves. This proposition is strikingly exemplified, by comparing the spinal cord of animals, whose superior are larger than their inferior extremities, with that of others, whose inferior are of greater size than their superior limbs.

I have already said that there is a mass of gray substance contained in the interior of each half of the spinal cord, proportionate, in quantity, to the volume of the corresponding parts of the same, and to the nervous roots that issue at the place. The gray substance is disposed in a crescent form on either side of the apparatus of union, towards which the concave aspects are turned. (Pl. i. fig. 9 and 10).

The white fibres of the spinal cord, on both abdominal and dorsal surfaces, follow the gray substance throughout its extent, so that there are two nervous roots in each half: one dorsal, another abdominal. (Pl. i. fig. 9 and 10.) The dorsal roots, generally, and the entire dorsal mass (Pl. i. fig. 9 and 10), are more considerable than the abdominal roots and corresponding half. The dorsal roots communicate with the intervertebral ganglions (pl. i. fig. 3, 4, *a—a*), and the latter are proportionate to the former.

No division of the spinal cord into dorsal and abdominal portions is effected by two such channels as separate it into halves laterally; it is, at most, only marked by the *ligamentum dentatum*

which attaches the cord, on either side, to the dura mater. (Pl. i. fig. 3, 4, 5, and 6.) Neither is it proper to look on the lateral portions of the spinal cord, as each composed of three bundles extending from its one to its other extremity. They are much rather to be considered as nervous membranes folded on themselves, and forming a tube, containing gray substance. (Pl. i. fig. 10.)

The fissures on the abdominal and dorsal aspects of the spinal cord, are quite constant. The first is shallower, but more conspicuous, than the other. (Pl. i. fig. 10.)

The abdominal nervous roots of the spinal cord communicate with the nerves of the thorax and abdomen ; those of the dorsal surface frequently inosculate, and filaments from one pair of nerves often run to join the fasciculi composing another. (Pl. i. fig. 5.)

Among the general considerations on the spinal cord, the question respecting its uses still remains for examination.

Anatomists have been in the frequent habit of speaking of a central mass in the nervous system, from which they conceive all its other parts to arise. The brain, cerebellum, and spinal cord, have very commonly been so entitled. M. de Blainville, however, separates the brain and cerebellum from the central mass. These he arranges along with the external senses and intervertebral ganglions under the general title, *Gan-*

glionary Portion of the nervous system, and he confines the central mass exclusively to the spinal cord and medulla oblongata. In his view, the ganglionary is only added to, and not derived from, or produced by, the central portion. The two nervous roots of the spinal cord are, he says, mere fibres of communication between the central part of the nervous system and the nerves of sensation and voluntary motion, which originate in the intervertebral ganglions.

To me anatomical, as well as physiological, facts, seem to militate against this opinion of M. de Blainville. In the first place, the intervertebral ganglions belong to the dorsal roots only of the spinal nerves. Our author, consequently, forgets to mention the origin and use of the abdominal roots entirely. But is it not probable, that both dorsal and abdominal roots arise in the same manner? The filaments of the spinal roots, too, are in proportion to the corresponding masses of the cord whence they issue. Now, as the abdominal roots have no intervertebral ganglions, and as they are evidently detached from the spinal cord, ought we not to conclude that the dorsal roots are so in like manner?

Another proof of the untenableness of M. de Blainville's notion, exists in the size of the nervous filaments of the spinal cord. The apparatus of communication is never so large as the parts that communicate; what a difference, for ex-

ample, between the volume of the nervous masses of vegetative and of phrenic life, and their communicating fibres!

Neither is M. de Blainville's opinion supported by physiology. The ganglionary portion, he conceives to be sufficient for the performance of its own functions, that is to say, adequate of itself to feel, and to cause the execution of voluntary motion; what then becomes of the central portion? what is its use? Admitting it to establish communications between the different parts of the nervous system, it cannot, however, exist solely for such a purpose; its volume is by much too considerable to permit such a supposition to be entertained. Again, it most certainly is not destined to the affective and intellectual operations, for there is no proportion between them and the developement of the spinal cord. On the contrary, it is certain that general sensation and voluntary motion are in direct relation to the volume of the nervous masses of the vertebral column. Animals, eminently endowed with these two functions, have always a considerable spinal cord, and its parts proportionate to the organs which receive their nerves from thence. The several parts of the spinal cord are also augmented, as the apparatuses of sensation and of motion are increased in number or size. Further, the spinal cord is developed at a much earlier period of life than the cerebral masses;

it has acquired solidity and firmness, while the brain is still pulpy and devoid of fibres; and in harmony with this law, children display great muscular activity,—their love of bodily exercise is insatiable, before their mental faculties appear in any degree of vigour.

M. Serres, who admits all the organic systems, the nervous in particular, to be developed from the circumference towards the centre, maintains that the nerves are fully developed when the spinal cord and brain are still in a fluid state. In conformity with this his hypothesis, he denies that the spinal cord gives origin to its nerves. These, according to him, are only implanted into it.

Dr. Bailly conceives, as I have said, the same nervous elements to belong to every particular vertebra, *i. e.*, nerves of sensation, of motion, of digestion, and of the intellectual functions. He speaks of eight cords that compose the intellectual system of the vertebral column: the inferior mediam cord, continuous with the pyramidal eminence, and terminating anteriorly in the celebral hemisphere; the lateral inferior cord, ending in the internal layer of the corpora quadrigemina; the superior lateral cord, which terminates in the cerebellum; and the inferior median cord, finishing in the lateral convolutions of the medulla,—convolutions which are most largely

developed in cartilaginous fishes, and which correspond to the ribbon of gray substance of mammiferous animals. These eight longitudinal cords, four on each side, according to this author, exercise functions analagous to those of the cerebral hemispheres, the internal slip of the quadrigeminal bodies, the cerebellum, and the lateral convolutions of the fourth vertricle in fishes, or the gray band in the mammalia. The medulla oblongata, in the same gentleman's view, presents alternately an intellectual cord and a nervous pair.

These physiological suppositions will, I make no doubt, share the fate of so many others, that are now forgotten. In my opinion, the spinal cord is, 1st, the origin of the nerves styled spinal; 2nd, an apparatus that contributes to muscular and sensitive powers; and 3rd, a means of communication between the cerebral operations, the sense of touch, the power of motion in general, and the functions of vegetative life collectively.

Particular Considerations in regard to the Spinal Cord.

Before the development of extremities in the embryo, in animals also that naturally have none, and in cases of monstrosity where they are want-

ing, the spinal cord has no enlargements. These appear with, and are in proportion to, the extremities.

In the lower animals the spinal cord extends farther into its bony canal than in the human kind. Up to the fourth month of the human embryo's existence, it runs to the extremity of the coccyx; but the peculiar structure, termed *cauda equina,* which is more remarkable in man than in any other animal, becomes more and more apparent after this period. The caudal appearance is produced by the sacral and lumbar nerves.

The spinal cord of the human kind commonly terminates by one or two little knobs, (of which the superior, when there are two, is the larger,) opposite to the second lumbar vertebra, and it is then attached by means of a tendinous slip to the bottom of the vertebral canal.

The spinal cord is commonly divided into four portions: a cervical, dorsal, lumbar, and sacral. Each of these detaches several pairs of nerves, the number of which varies in different species of animals; in man it amounts to thirty pairs, five being sacral, a like number lumbar, twelve dorsal, and seven cervical.

The spinal cord of man, as of animals, is enlarged, and contains a larger quantity of gray substance at those places where the great nerves of the extremities are detached, than at any

other. Although many anatomists, M. Serres among the rest, deny that the spinal cord of man and animals is enlarged at, and contracted between, the origins of each pair of nerves, I still adhere to the opinion which, in conjunction with Dr. Gall, I published long ago ; and I again appeal to nature for confirmation of its accuracy. These alternate enlargements and contractions are more or less conspicuous, in the ratio of the volume of the nervous pairs ; they are, for instance, more apparent in the ox and horse than in man. If, however, the human spinal cord, stripped of its dura mater, and arachnoid covering, be held profile-wise against the light, the undulated line of its edges will be abundantly obvious. In the large work on the "Anatomy of the Brain and Nervous System," we have given drawings of this structure from the spinal cord of the calf and of man. Pl. i. fig. 3, is a portion of the spinal cord of a calf.

Several anatomists have spoken of numerous transverse folds to be observed, especially on the abdominal surface of the spinal cord ; these become very distinct when the cord is taken from out its bony canal, and one end is brought towards the other ; they disappear entirely, however, when the part is stretched. Such folds, therefore, appear to result from the bending of the cord, and not to belong to any original peculiarity of organization.

On either side, and at some little distance from the great median fissure, two superficial channels may be observed on the dorsal surface of the human spinal cord (pl. i. fig. 5, α—α.) They extend as far as, or a little way beyond, the first dorsal vertebra. The two bands between the median and these superficial fissures, are developed at the earliest period; their structure is even complete, when the rest of the spinal cord is still a grayish and pulpy mass. The bands on the external edges of the dorsal and abdominal median fissures, appear, in general, to attain maturity of structure before any of the lateral masses.

By opening the mesial abdominal fissure, and stripping off the vascular tissue, the nervous fibres will be seen running lengthwise and parallel to the lateral bands, (pl. i. fig. 6;) but in the dorsal cleft, they will be found descending perpendicularly from the surface towards its bottom. (Pl. i. fig. 7.)

The structure of the apparatus of union has not the same appearance at the bottom of both fissures. If the edges of the one on the dorsal aspect be gently separated, two white bands will be discovered running lengthwise (pl. i. fig. 7, ϑ—ϑ), almost as occurs in the middle line of the great cerebral commissure (raphe of the corpus callosum); at the bottom of the abdominal fissure, on the contrary, filaments will be observed running transversely from the sides towards the median line.

These bundles do not meet, they rather interlace, each terminating on either side between the two that come from the opposite side. (Pl. i. fig. 6, 9—9.)

Besides the peculiarities of its shortness compared with the vertebral canal, and of its termination in the cauda equina, the spinal cord of man presents another striking peculiarity in the direction in which its nerves are detached. The direction in which the spinal nerves are sent off, varies widely in different classes of animals. In man, their course is downwards and outwards; this depends evidently on the vertical posture, by which man is distinguished from the other mammalia, and on the shortness of his spinal cord compared with its bony canal. In the human kind, only the first pair of cervical nervous roots on the dorsal surface (pl. i. fig. 5), and the two first pairs upon the abdominal (pl. i. fig. 4), have one set of bundles coming from above, downwards, and another from below, upwards; all the other pairs are detached more and more obliquely downwards, to gain the vertebral holes by which they issue, in proportion as they arise nearer to the sacral extremity of the spinal cord. In other animals, on the contrary, whose spinal nervous masses occupy the entire length of the vertebral canal, the nerves are sent off directly opposite to the intervertebral spaces at which they issue. (Pl. i. fig. 3.)

I have still to speak of the superior extremity

of the spinal cord. By the words spinal marrow or cord, most anatomists understand the nervous mass that extends throughout the spinal canal up to the occipital hole; others, Messrs. Sœmmerring and Chaussier among the number, say that it goes as far as the annular protuberance. They consequently include the pyramidal and olivary bodies, the accessory, vocal, glossopharyngeal and hypoglossal nerves, all the mass, in short, commonly named *medulla oblongata.* They speak of two portions—one *cranial,* another *spinal,* of the spinal cord; the first being, of course, contained in the skull, the second in the canal of the vertebral column.

The organization of the spinal nervous mass cannot be said to change entirely when it enters the cranium: several pairs of nerves are still detached precisely in the same manner as they are in the spine; the nerves too, in both cases, perform similar functions. The proper spinal masses are also intimately connected with those of the medulla oblongata. In this last part, however, the abdominal fissure is interrupted by the decussating bundles of the pyramidal bodies; the size of the mass is also very sensibly increased here, and there is no regular proportion between the proper spinal cord and the mass that extends from the occipital hole to the annular protuberance. Moreover, the roots of several cerebral nerves, as they are styled, are found in this last mass, as also the

rudimentary parts of the brain and cerebellum. Lastly, the word *spinal* refers to a particular situation—the spine. These reasons may suffice to make us limit the title *spinal* cord to the mass included in the vertebral canal, and extending from the occipital hole or commencement of the pyramidal decussation to the cauda equina or horse's tail.

CHAPTER II.

Of the pretended Cerebral Nerves; or, of the Cranial Nerves of the External Senses and Voluntary Motion.

It is usual for anatomists to consider the nervous mass lying between the occipital hole and annular protuberance, as distinct and particular. In former times, this part was taken for a prolongation of the brain and cerebellum, and, therefore, called *medulla oblongata*. In man it is composed of parts, named severally, pyramidal bodies, which are two in number, anterior (pl. vi. fig. 1., 1—*c*.) and posterior (pl. xi. in the middle line); olivary bodies (pl. vi. fig 1, *a*.); restiform bodies (pl. xi. *e*. *e*.); accessory nerves (pl. i. fig. 3, 4, and 5; pl. vi. fig. 1, 2—3); hypoglossal nerves (pl. vi. 4); vocal nerves (ib. 6); glossopharyngeal

nerves (ib. 7); auditory nerves (ib. 9); facial nerves (ib. 11); and abductor nerves (ib. 10.)

At the conclusion of the last chapter, I remarked that it was a mistake to confound the part called medulla oblongata and the spinal cord together. I here subjoin that the medulla oblongata is not a separate and particular nervous mass: it gives origin to the nerves above-mentioned, and also to the fifth pair; but there is yet one portion of each of its halves which belongs, decidedly, to the cerebellum, and another which pertains to the brain.

The volume of the medulla oblongata varies greatly in the different classes of animals; its size is determined by the nerves that arise from it, and by the bundles that proceed to the cerebellum and brain. Its increase beyond the size of the spinal cord, is more remarkable in reptiles than in fishes, in birds than in reptiles, and is especially considerable in the mammalia, which, generally, have the medulla oblongata as well as spinal cord proportionately larger than man, because the nerves detached from these parts are larger in them than in the human kind.

At present, I mean only to speak of the supposed cerebral nerves. The pyramidal, olivary, and restiform bodies will be examined along with the cerebellum and brain of which they are parts.

The opinions of authors upon the origin of the nerves of the head are very various. In general

they are derived from the brain, hence their name *cerebral.* But some writers limit the title *brain* to the hemispheres, and join the striated bodies, the optic thalami, the cerebral legs and annular protuberance to the medulla oblongata; or, otherwise, they look on all these as parts of the spinal cord, and then say that no nerve whatever arises from the brain, that is, from the hemispheres immediately. By thus extending the limits of the medulla oblongata and spinal cord, however, parts that belong essentially to the brain are included. The principle we lay down, therefore, that no nerve originates in the brain, and that every nervous part has its own origin, so that the nerves can no more be derived from the brain than can the various nervous pairs from each other, cannot possibly be confounded with any of the foregoing opinions of authors.

The proofs we adduce in support of our position, as to the independent origin of the various nervous parts, are constantly the same; all, therefore, that has been said to demonstrate the spinal cord to be no continuation of the brain, applies to the nerves of the head, and proves that they do not owe their being to the brain, and that no one pair derives its existence from any other. In the first place, the nerves of the head bear no proportion to the brain in size; and then, these nerves exist in acephalous monsters, whose brain never had being. Moreover, the course taken

by the nerves towards the cranial holes through which they pass, proves in the most positive manner that they are not continuations of the cerebral fibres. In examining the individual nerves, I shall speak of their several peculiarities, as origin, structure, and connexion are concerned.

The nerves of the head, as of the spine, have been long classed into pairs. The number of pairs reckoned, however, varies considerably; sometimes they are said to be seven, sometimes eight, or nine, or according to M. Sœmmerring's method of counting as many as twelve. However, the mode of indicating the several pairs of nerves numerically, and speaking of the first pair, the second pair, the third pair, and so on, possesses no practical advantages, because, besides the number, the functions of each pair must still be learned. It is better, therefore, to designate each pair of the cranial nerves in succession from its functions or its destination.

Some authors have divided the nerves according to their places of detachment, into nerves of the brain, of the cerebellum, of the annular protuberance, and of the medulla oblongata. This attempt at classification was necessarily very deficient, for it is based upon an error in regard to the origins of the nerves; the actual place of origin being confounded with that at which they issue immediately from the general mass.

Of the Accessory Nerve.

The accessory nerve is found in man and the other mammalia. (Pl. i. fig. 3, 4, 5, and pl. vi. fig. 1, 2—3.) It arises from the cervico-spinal mass and medulla oblongata. Its filaments come from the dorsal surface of these parts, and vary in number, in thickness, and in length, not only in different individuals of different species, but even on the two sides of the same subject. The first filaments are detached at various heights, sometimes higher, sometimes lower, in the spinal cord, issuing from the level of the seventh cervical pair in one instance, and from that of the fifth in another. The accessory recedes from the spinal cord and medulla oblongata, as it approaches the pneumogastric nerve, along with which it escapes from the cranium. I have already said, that Mr. Charles Bell arranges the accessory among the nerves of respiration. In contributing to this function, it produces motion, and is influenced by the will; nevertheless it is detached, as we have seen, from the dorsal surface of the spinal cord.

Of the Pneumogastric Nerve.

The pneumogastric occurs in all vertebral animals. In man (pl. vi. fig. 1, 6), it issues by nu-

merous filaments between the olivary, (ibid *a*,) and the restiform (*e e*) bodies, nearer to the latter, however, than to the former. It unites with a great number of other nerves, a circumstance that has obtained for it the title *vagus*. Its branches run to the larynx and pharynx, to the thyroid gland, the vessels of the neck, and the great conduits of the heart, to the lungs, the liver, spleen, pancreas, stomach, and duodenum. As some of its principal branches are distributed to the organs of voice, and as its lesions derange the functions of these parts, it has also been called the vocal nerve. The communications by its means established, and its extensive distribution, explain the sympathies that exist between the throat, lungs, stomach, heart, &c.

Of the Glossopharyngeal Nerve.

In the mammalia and man, (pl. vi. fig. 1, 7,) this nerve comes off from the medulla oblongata, just before the pneumogastric, by a great many filaments, which, speedily uniting into one or more bundles, compose a trunk that runs to be ramified on the pharynx and muscles of the tongue. It appears to be destined to general sensation.

Of the Hypoglossal Nerve.

The hypoglossal in man arises partly near the olivary and pyramidal bodies, and partly lower down, by several filaments that are detached, and get united after the manner of the cervical nerves. (Pl. vi. fig. 1, 4.) It supplies the tongue with motive power, and acts in mastication, deglutition, speaking, singing, &c.

Of the Abductor Nerve of the Eye.

This nerve arises in all mammiferous animals, from the abdominal surface of the medulla oblongata. (Pl. vi. fig. 1, 10.) In some, as the horse, ox, and deer, it mounts all the way along with, and by the side of, the pyramidal bodies, in the form of a band, which, on reaching the annular protuberance, divides into two. In the human subject it is generally covered by some transverse fibres of the protuberance. Its distribution, as its name implies, is to the abductor muscle of the eye.

Of the Facial Nerve.

The facial is detached from the spinal cord in the same manner as the nerves I have just discussed. Its true origin is readily seen in the

lower animals; but in man, (pl. vi. fig. 1, 11,) it (or some of its filaments at least) seems to come from the annular protuberance. This happens in consequence of its being covered entirely, or partially, by the transverse fibres of the part mentioned. The distribution of this nerve is to the muscles of the face; it also communicates freely with all the three branches of the fifth pair.

Of the Motor Nerve of the Eye.

The filaments composing this nerve, (pl. vi. and pl. x. fig. 1, 15,) issue from the blackish body of the cerebral legs (pl. x. fig. 1, 30); these unite and go to supply the superior, internal, inferior straight, and inferior oblique, muscles of the eye, and the elevator of the upper eye-lid. It is detached in all vertebral animals, from the cerebral crura behind the *tuber cinereum*, or ash-coloured tubercle, (pl. vi. 17,) which is situated immediately backwards from the junction of the optic nerves.

Of the Nerve of the Superior Oblique Muscle of the Eye.

This nerve, (pl. vi. 13,) springs by several filaments behind the posterior pair of quadrigeminal bodies in the mammalia, (pl. xi. fig. 1, *o*,) and

behind the bigeminal bodies in the other classes of animals. It has no prerogative over the other nerves of motion in expressing the affections and passions; the name *patheticus*, or ogling nerve, therefore, which it has obtained, is misapplied. Although a nerve of motion, it arises from the dorsal surface of the nervous mass.

Of the Trigeminal Nerve.

The trigeminal (pl. vi. fig. 1, 12) arises from the medulla oblongata. Its place of origin is apparent in those animals, as reptiles, birds, and fishes, which have no annular protuberance, and also in the mammalia which have it of small size; but in man, the monkey, and other tribes, where this part is very large, the trigeminal seems to arise from it; the nerve, however, is, in fact, only covered by some of its transverse fibres, (pl. viii. fig. 1, *i*—*k*.) and the origin of the nerve is, in fact, the same in all animals. To shew it in the human kind, the fibres of the annular protuberance that cover it, must, of course, be dissected away.

The trigeminal nerve is distributed to every part of the face, to the muscles of the forehead, of the eye-lids, nose, lips, jaws, and ears; it communicates with the organs of all the five senses, and of voluntary motion, and brings these and the other parts of the body, the face,

neck, trunk, and extremities, into relationship mutually.

One branch of the trigeminal is ramified on the tongue, and is regarded as the true gustatory nerve. It is, therefore, destined to cognize an impression of a specific kind, *viz.*, taste. If some feel disposed to regard taste as a sort of touch, they must, at least, admit the impossibility of confounding or assimilating this species of perception with sensation in general.

Of the Auditory Nerve.

The auditory (pl. vi. 9), as well as the nerve last discussed, must exist in the avertebral tribes, but its origin and peripheral expansion only become distinct and complex as we ascend in the scale of beings. The origin of the auditory nerve is in many fishes confounded with that of the facial and trigeminal; in some kinds, however, it is more distinct, and is the same as in reptiles and birds. The auditory nerve always arises laterally and posteriorly to the cerebellum. In the mammalia it comes from the fourth ventricle, and traverses in its course a band of gray substance, lying between the restiform body and the cerebellum. In man certain white lines may commonly be seen in the fourth ventricle, (pl. ix. fig. 1. *t.*) which Piccoluomini was the first to consider as the origins of the auditory nerve. These

lines, or streaks, are almost imperceptible in some subjects, but in others they are very numerous and distinct. They are observed to vary on each side, being occasionally larger and more numerous on one than on the other Sometimes they occur disposed in rays, sometimes in pencils, and, again, they run in parallels, often lying higher on one than on the other side. They at one time appear as little flattened bands, at another as rounded and salient cords. Piccoluomini's opinion of their use seems now to be very generally adopted; it is certain, indeed, that some of them do unite with the auditory nerve, but others run to the anterior cerebellar lobes, and others dip into the middle of the cerebellum. Although many of the mammalia have much larger auditory nerves than man, these white fibres are nevertheless wanting in all. In them, there is a broad band on either side, extending from the one auditory nerve to the other, immediately behind the annular protuberance, and above all the ascending bundles, except the pyramidal bodies. (Pl. iv. fig. 2, *c.*) This band appears to be an apparatus of union or commissure. It does not give origin to the facial nerve, as some anatomists have supposed.

Of the Optic Nerve.

Since the days of Eustachius and Varolius, the

majority of anatomists have derived this nerve (pl. vi. fig. 1, 20.) from certain masses, which have, in consequence, been entitled thalami of the optic nerves. (Pl. x. fig. 1, *p*.) Others, however, followed some of its fibres backwards to the anterior of the quadrigeminal bodies. (Pl. xi. fig. 1, *n*.) And it is easy in the mammalia to do this. A broad slip issues from the anterior quadrigeminal body of either side, which turns round upon the outer edge of the thalamus, simply superimposed upon the cerebral crura, but attached to the neighbouring masses along its external edge, as far as its junction with its fellow of the opposite side. (Pl. viii. fig. 1, *w*, *w*, *w*.) From the tuber cinereum, (pl. vi. fig. 1, 17.) the optic nerve receives many additional fibres, which join it in right lines, and without decussating. (Pl. viii. fig. 2, 20.)

It is the opinion of many anatomists, that the optic nerves, at their junction, unite intimately without decussating; many others, on the contrary, think that either nerve crosses to the side opposite to that on which it had arisen. The numerous cases described by authors, and the facts which Dr. Gall and I have collected, prove that atrophy of one optic nerve is continued on the opposite side after the junction of the two.

We, therefore, agree with those who recognise a partial decussation of the optic nerves in man and the mammalia. The fibres of the outermost

portions appear to continue their course onwards without decussating.

It was a great error to consider the eminences called optic *thalami*, as the sources of the optic nerves. There is, in fact, no proportion whatever between these parts and the nerves of vision. In the horse, ox, sheep, &c., the optic nerves are as large as in man, but the thalami, in the human kind, are much larger than in these animals.

A very cursory examination of the structure of the thalami also shows a mere superficial layer attached to the optic nerve and the whole of the interior fibres proceeding in a divergent manner, backwards, to be distributed to the cerebral convolutions. (Pl. x. fig. 1, *p.* P. P.)

When the optic nerve is affected with atrophy, the corresponding thalamus is diminished only in as far as the nerve itself is lessened; the interior of the thalamus suffers no change, but the atrophy of the nerve continues on to the anterior quadrigeminal body which belongs to it. I once found, in the brain of a woman who had died insane, the thalamus of the left side half converted into pus; the corpus striatum of the same side was also much shrunk, but the optic nerve was healthy, and resembled, in all respects, its fellow of the opposite side, in the vicinity of which no organic change could be detected. The anterior pair of quadrigeminal bodies were also in their natural state.

The two thalami are rarely of equal size; the one on the left side is commonly the smaller. It, therefore, becomes necessary to guard against attributing to atrophy of an optic nerve an appearance that depends on natural conformation.

Until Dr. Gall and I showed the mistake, the optic tubercles of birds and reptiles were confounded with the thalami; these tubercles (pl. xi. fig. 2 and 3, *n.*), however, correspond to the anterior pair of quadrigeminal bodies. The parts, called thalami (pl. xi. fig. 2, *p.*), also exist in the two classes of creatures mentioned, besides the true optic ganglions, (ib. *n.*)

It is a difficult matter to say whether the long elevated bodies that occur immediately behind the crossing of the optic nerves in fishes (pl. ii. fig. 4, 6, 8, 16), and correspond to the optic ganglions of birds, that is to say, to the pair of ganglions (pl. iii. fig. 5, 6, 7, 10, and 11, *n.*) which comes immediately after the cerebellum, or whether they ought to be likened to the bodies which are styled mammillary. (Pl. vi. fig. 1, 16.) The optic nerves of fishes seem to arise from, at all events they communicate with, these bodies. By comparing pl. ii. fig. 4 and 6, 16, with pl. iii. fig. 12, *n.*, the optic ganglions in birds, and especially in mammiferous animals, will be seen to be separated and pushed upwardly and laterally by the medulla oblongata, cerebral legs, and annular protuberance. Moreover, the optic nerves in fishes adhere

to several other parts, as they do in the higher classes of vertebral animals and in man. It is from this circumstance that a great part of the other masses, especially those that follow the cerebellum, are called optic ganglions; but these bear no proportion to the optic nerves (pl. ii. fig. 5, 7, and 10, *n*.), and to me, it seems more reasonable to allow, with M. Arsaky *, that the complicated structure of the optic ganglions in fishes, explains the functions of the derived nerves, which, in reptiles, birds, and the mammalia, are evidently aided in their functions by the other parts with which they communicate.

The implantation of the optic nerve in fishes into the inner edge of its ganglion, which causes the greatest part of this mass to appear before and above it, bears a striking analogy to the adhesion of the same nerve to the brain in other classes of animals, and confirms the idea in question. It is rendered still more probable, as the same peculiarity of structure is found in connexion with the olfactory nerves of fishes. And further, the oblong bodies, which, in fishes, lie behind the crossing of the optic nerves, cannot possibly be supposed analogous to the mammillary bodies of mammiferous tribes, because these last belong to the fornix, and this is a part which fishes have not. I may still add that the mammil-

* Dissertatio de Piscium Cerebro et Medulla Spinali; Halæ. 1813.

lary bodies bear no proportion to the optic nerves, and that the oblong bodies of fishes above-mentioned do, regularly.

The oblong bodies of fishes, probably, correspond to the gray tubercle, (tuber cinereum) of the mammalia. This tubercle, in the higher classes of beings, always sends fibres to the optic nerves, which, after this accession, advance of increased size in their course. (Pl. viii. fig. 2—17.)

The connexion of the optic nerve with such a number of cerebral parts, renders its exact origin uncertain. To appreciate this truth in its full force, it will be necessary to reflect on what I have still to say of the quadrigeminal bodies.

Of the Quadrigeminal Bodies.

The title, corpora, or tubercula quadrigemina, is applied to two pairs of round elevations, situated behind the legs of the brain. They are only found in the mammalia and in man. (Pl. xi. fig. 1, *n*, *o*.) They are joined together by a transverse band (ib. *x*), and they communicate with the part called valve of Vieussens (ib. *y*), with the bundles that proceed from the medulla oblongata, and with the pretended optic thalami (ib. *p*.). I have already spoken of the large band, belonging to the optic nerve, that issues from the anterior pair of these bodies. Being in communication with the bundles which come from the posterior

part of the medulla oblongata, there can be no doubt but the quadrigeminal bodies have their origin lower down in this nervous mass; but as the optic nerves arise from the anterior pair in the mammalia, and as these nerves issue in birds from a couple of ganglions, separated from the general cerebral mass, (for, in birds, they are only united to the bundles that proceed from the medulla oblongata) the analogy and office of these ganglions cannot be called in question. The destination of the posterior pair of quadrigeminal bodies is much less obvious.

M. Serres* thinks that the bigeminal tubercles of fishes, reptiles, and birds, and the quadrigeminal bodies of mammiferous animals and man, are the same mass, destined, in all, to originate the optic nerves, and that the division into two pairs happens merely from a transverse furrow, which, as it runs more or less forwards or backwards, equalizes them, or causes in one case the anterior, in another the posterior pair to predominate.

The posterior are intimately connected with the anterior tubercles, it is true; but there is a white band which issues from the anterior pair, joins a small collection of gray substance, called *corpus geniculatum externum* (pl. viii. fig. 1, *q*), is thereby increased in size, and then continues its course into the optic nerve; in like manner there

* Anatomie du Cerveau; Préface. Rapport de M. Cuvier.

runs a band from the posterior pair, which unites with a mass of gray substance, entitled *corpus geniculatum internum* (pl. xi. fig. 1, *r.*), and gaining, consequently, in size, afterwards dips under the optic nerve, and is continued on towards the middle cerebral lobe. This structure proves, at the least, that the anterior and posterior pairs of the quadrigeminal bodies are no parts of one and the same nervous mass.

M. Serres also fancies that the corpora quadrigemina serve as a basis, according to which the other parts of the encephalon are determined ("*les tubercules quadrigeminaux servent de base à la détermination des autres parties de l'encephale*);" and he investigates their relations with many particular cerebral parts. His assumption seems to me as incorrect and untenable as the one I have just examined, according to which, the quadrigeminal bodies are parts of one mass similar to the bigeminal tubercles of birds and reptiles.

"The quadrigeminal tubercles," says M. Serres, "are developed in all the classes, and in every family of each class, in a ratio, directly as are the optic nerves and the eyes. Fishes have the largest quadrigeminal tubercles, and the most remarkable eyes and optic nerves. The very considerable size of their quadrigeminal bodies, indeed, has led anatomists, up to the present time, into the error of supposing them to be the hemispheres of

the brain. After fishes come reptiles, then birds, next, among mammiferous animals, the rodentia, and in succession, the ruminantia, the carnivora, the quadrumana and man."

I have already shown, that in fishes generally, the ganglions called optic, are disproportionate in size to the nerves of vision; and I have said that part of these masses was, probably, destined to other functions. The optic nerve of the carp (pl. ii. fig. 4, 20) is smaller than that of the roach (pl. ii. fig. 11, 20), but the so styled optic ganglions (ib. *n.*) exist in these fishes in an inverse proportion.

"The spinal marrow and the corpora quadrigemina," says M. Serres in another place," are so rigorously developed in the ratio of each other that the size of the first being given in any class or in any of its families, the volume of the latter may be determined with precision."

But the bigeminal tubercles in the carp (pl. ii. fig. 5, *n.*) are much larger, in proportion to the spinal cord, than in the eel (pl. ii. fig. 1) and the roach (pl. ii. fig. 11.). M. Serres, himself, has given representations of the optic apparatus in the cassowary, ostrich, and other birds, much larger in proportion to the spinal cord, than it is in the many mammiferous animals whose brains he has figured; and the disproportion between the developement of the quadrigeminal bodies

and spinal cord, is even greater in the dolphins and porpoises, than in the ox, camel, and horse.

The most cursory glance over the physiology of living beings also shows the utter erroneousness of M. Serres's position. Powers of voluntary motion and of touch never bear any direct proportion to the faculty of vision. The mole is, certainly, far more remarkable for its muscular strength than for its eye-sight, and the owl for its powers of vision than for its bodily vigour.

I shall discuss the several relations which M. Serres believes he has found between the quadrigeminal bodies and other parts of the nervous system, as I treat of these in succession.

M. Bailly, in his Memoir on the Comparative Anatomy of the Nervous System in the four Classes of Vertebral Animals, maintains that the corpora quadrigemina anteriora et posteriora, the corpora geniculata externa et interna are mere parts of the optic lobe of inferior classes. He speaks of the unfolding of the quadrigeminal bodies in fishes, and of two systems of fibres very different from each other: the one exterior and belonging to the optic nerves; the other interior, and being the expansion of a cord of the medulla oblongata. "In fishes and reptiles," says he, "the internal have a much greater relative developement than the external fibres; in mammiferous animals, the external fibres alone remain; the internal exist as mere rudiments."

Dr. Gall* also says he is "convinced that the posterior pair of the corpora quadrigemina is a ganglion, for the purpose of reinforcing or perfecting the optic nerve." He adds, "the modes in which these two pairs assist the function of vision must differ, for they occur in various proportions to each other, in the different species of animals; in some, indeed, the posterior two are scarcely perceptible, or are even entirely wanting, although vision be perfect, as happens in the case of birds."

This diversity of opinion is to be accounted for, by recalling to mind the delicacy of the cerebral organization, and the intimate connexion of the parts with each other. When anatomists observe one or two parts connected together, they very commonly conceive the one to be derived from the other. By-and-by I shall treat, in a separate section, of the communications of the nervous masses, and of the importance of this arrangement. Meantime, I shall pass my opinions respecting the quadrigeminal bodies in review before my reader.

The mammalia alone have quadrigeminal bodies. Both pairs, however, have not, I conceive, similar offices, for there is no proportion between them indiscriminately, nor the bundles of fibres which issue in different directions from each. The fibres of the anterior pair, as I have said, join the

* Sur les Fonctions du Cerveau.—Ed. in 8vo. Vol. vi. p. 55.

optic nerves, those of the posterior plunge under the optic nerves, and are lost on the middle lobes of the brain. The optic nerve communicates, by means of superficial bands, with the posterior pair of the quadrigeminal bodies, with the internal and external geniculated bodies, with the middle and anterior cerebral lobes, and with the mass called tuber cinereum.

Reptiles and birds have only one pair of rounded tubercles, before and by the sides of the cerebellum. (Pl. iii. fig. 2, 3, 4, 5, 7, 10 and 11, *n.*) These are readily seen, by throwing back the cerebellum. On examining their structure, they are found, in the first place, to be hollow (pl. iii. fig. 9, side B. *n.*), and to detach a superficial layer that communicates with the medulla oblongata behind, and with the optic nerve and base of the brain before ; and, in the second place, to be connected by their lower parts with the optic nerves and the cerebral crura or legs. This structure of the optic ganglions in birds and reptiles, corresponds to that of the anterior pair of the quadrigeminal and external geniculated bodies in mammiferous animals, as in them the one and superficial layer of the anterior pair is continued into the optic nerve, whilst the other and deeper is connected with the crura of the brain.

In fishes, the optic nerves always communicate with the basis of the pair of tubercles that succeeds the cerebellum, and this pair is connected

with the medulla oblongata; but it and the optic nerves have not, mutually, any regular or fixed proportion, whilst the optic nerves and the rounded tubercles that lie immediately behind their crossing, are constantly developed in the ratio of each other. The optic nerve, in fishes, moreover, communicates with the basis of the cerebral masses that come after the cerebellum, precisely as it is connected in the mammalia with the anterior and middle lobes of the brain.

In proportion, therefore, as the cerebral masses and fibrous bundles, or their successive additions, diminish in number through the four classes of vertebral animals, the primary optic ganglions approach each other, and lie between or among such cerebral parts as still exist; but as the brain gets complicated, and vision exerts an important influence upon its functions, the primary optic ganglions lie backwards, in order that the apparatus of vision may, conveniently, be brought into communication with the cerebral parts whose functions it especially aids.

Of the Olfactory Nerve.

Very different opinions have been, and are still entertained by anatomists in regard to the origin of the nerve of smell. Some of the moderns have described it as arising from the masses called striated bodies; but there is no proportion, what-

ever, between them and the nerve; and further, porpoises and dolphins have the striated bodies, but no olfactory nerves. The nerves of smell also exist in many acephalous monsters, whose striated bodies are, of course, wanting.

The olfactory nerve, in the human kind, has three roots; of these, the interior (pl. vi. 21) is the shortest, but broadest, and the exterior the longest (ib. 18), for it extends to the bottom of the fissure of Sylvius. These different roots are, as it were, impacted in the cerebral substance; they approach by degrees, and having met, advance in the form of a single nervous trunk. In man, the nerve parts from the anterior lobe at the place where the convolutions commence, and runs along the cleft formed between the innermost of the anterior and inferior of these, accompanied throughout its whole course by a very distinct streak of cineritious substance. Immediately above the cribriform plate of the ethmoid bone, it encounters a considerable quantity of very soft gray substance, with which it forms a sort of bulb. (Pl. vi. fig. 1, 23.) The nerve, here, gains a mighty increase in size, and passing by numerous filaments through the cribriform plate of the ethmoid bone, it is lost upon the lining membrane of the nose.

The olfactory nerve of monkies (pl. v. fig. 3), and of seals, resembles that of man very nearly. In the class mammalia, generally (pl. iv. fig. 2)

a great many nervous fibres may be seen arising from the anterior part of the middle cerebral lobe; these join the fibres that spring from the inferior surface of the anterior convolutions, and compose a broad and rounded band, which, remaining attached to the anterior lobe, runs slightly inwards until it arrives at the ethmoid bone, when, precisely, as in man, it meets a large mass of gray substance (pl. iv. fig. 2, 3, and 4, 23), and increases in size so much, that after its exit by the ethmoidal holes, it suffices to cover the entire surfaces of the large superior spongy bones.

The bulb that is formed over the ethmoid bone, if it be incised, or have a piece taken out, will be found to be hollow. Its internal white layer in the lower animals communicates immediately with the anterior cavity of the brain, so that by blowing into the bulb of the olfactory nerve, the air will penetrate and inflate the lateral ventricles. Sœmmerring says, that the olfactory nerve of the human embryo, at an early period, is also hollow, and that air blown into it reaches the cavities of the brain. The same experiment will, occasionally, though very rarely, succeed in the adult. When we observe the olfactory nerve so very large in the mammalia, whilst the mass of anterior convolutions is but inconsiderable, and, on the other hand, the nerve in the human kind so small and surrounded by the thick masses of the anterior lobe, we may conceive why the experiment

should succeed so readily in animals, and be so rarely practicable in man.

The olfactory nerve, it may be almost unnecessary to state, is proportionate in size to the extent of external apparatus over which it is distributed.

In birds the nerve of smell is detached from the anterior and inner part of the front lobe, but its fibres are distinct from those of the brain; one of its bands too, which may be compared with the external root of the same nerve in man, runs towards the fissure of Sylvius and the middle lobe. This band, however, is not equally apparent in all birds. It is still less distinct in reptiles.

In fishes the olfactory nerve arises by two very distinct roots; certain fibres of great delicacy bring it into communication with the foremost cerebral ganglions, and others of a firmer texture and whiter colour connect it with the longitudinal band, which, in these animals, lies in the middle line between the various ganglions, and communicates with the medulla oblongata. (Pl. ii. fig. 9 and 13.)

Some anatomists have considered the entire mass of the anterior cerebral ganglion in the skate (pl. ii. fig. 3, 1, 2, 3), and all the three pairs of ganglions in the eel (pl. ii. fig. 1, 1, 2, 3), as destined to originate the olfactory nerve. But the error here committed is proclaimed by the fact

of the origins being always in proportion to the nerves themselves, and there being none whatever between the masses mentioned and the olfactory nerves of fishes. In regard to these ganglions, therefore, that which has been stated respecting those of vision must be repeated: the olfactory nerve is in communication with cerebral parts, destined to affective and intellectual functions.

Section IV.

Of the best Method of dissecting the Brain.

Before Dr. Gall and I began our researches on the structure of the brain, anatomists, in their dissections and descriptions, had no other object in view than to know the forms of the whole, or of its particular masses, the colours, connexions, and consistency, of its individual parts. To attain their end, they were in the habit of cutting down the brain by slices, and examining and noting the appearances presented by each in succession, until they arrived at the base. " The most accredited method," says M. Cuvier *, " of the schools, and usually recommended in books of anatomy, is to take away successive slices of the organ (the brain), and to remark the appearances offered by each. This is the easiest in practice for the demonstration, but it is the most difficult for the imagination. The true relations of parts, which are always seen cut across, escape not the pupil alone, but the master himself."

Willis † was the first who objected to the

* Rapport des Commissaires de l'Institut de France, on our Memoir, entitled " Recherches sur le Système Nerveux en Général, et sur le Cerveau en Particulier."

† Cerebri Anatomia.

practice of considering, as distinct parts, all the forms accidentally produced by such a mode of dissection. He himself viewed the cerebral parts in their connexions. He says too, that the anatomical demonstration of the brain should be begun at the basis; by basis, however, let me observe, he understood the striated bodies and thalami. Ascending from these to the superior parts, and returning on the inferior in succession, his attention was confined to the larger masses, which he designates by names that indicate physical qualities only. "From the striated bodies," for example, he says, "the legs of the medulla oblongata are prolonged; remaining apart for a short way, they then approach and get blended into a common stalk, composed, as it were, of two peduncles or stems."

As the Committee of the French Institute have conceived themselves authorized to assimilate the method of dissecting the brain, described in our Memoir, with the plan pursued by Varolius and Vieussens, and have interpreted these authors in a way which their language will not bear, I hope it will not be found amiss, if I extract a few passages from our Memoir, following them by some observations on the report.

"The brain," say the Committee, "is attacked from below; the medulla oblongata is pursued across the bridge of Varolius, through the thalami of the optic nerves, and the striated

bodies, when its fibres expand and compose the hemispheres. The hemispheres also, if we choose, may, by tearing their lateral attachments to the crura cerebri, be unfolded, the medulla oblongata and cerebellum be split longitudinally, and each half of the former shewn as a sort of stem implanted into the hemisphere of its own side, like the stalk of a mushroom into its cap." They add, " It is probable that this method would have had more vogue, were it not expressed in a rude drawing by Varolius, and had not the work of Vieussens remained, it would be difficult to say wherefore, in a sort of discredit, which it by no means deserves."

In reply to this we cite the following passages, from the works of the two authors mentioned above *. " The generality of anatomists," says Varolius, " think the spinal marrow begins at the occipital hole only ; I can bring proof to the contrary. It arises on the one hand below the ventricles of the brain, and on the other from the middle and inferior part of the cerebral basis. In the same manner as the brain, from out its substance, first produces that considerable trunk, the spinal marrow, from which the ocular nerves soon arise ; in the same manner the cerebellum pushes from itself a considerable process, which

* Constantii Varolii Anatomicæ, sive de Resolutione Corporis Humani Libri Quatuor. Frankforti, 1591 ; and, Vieussenius, Neurographia Universalis.

I call bridge of the cerebellum, out of which the auditory nerves then issue *." "That the sense of touch may inhere in all parts, and that all parts may convey images of objects, cognized by touch, to the primary sensorium, there are four roots issuing from the brain and cerebellum to form a considerable trunk, the spinal marrow, from which nerves are sent off and distributed to every part of the body †." "For my part, seeing that there were several cerebral organs situated about the base of the head, and that the brain by its weight (especially in the dead) compressed these against the skull, I deemed the ordinary mode of dissection liable to many inconveniences. This is the reason why I am in the habit of commencing the dissection at the opposite part of the head; that is to say, at the basis of the brain, and by so doing, each of its organs is so clearly exhibited, that it seems as if nothing further could be desired. This method, however, which differs from the usual one, is also very difficult ‡." Let any one read Varolius's letter to Mercurialis, and he will be convinced, from his entire description, that he confined himself to the various forms and appearances visible in the brain and cerebellum; that he did no more than attack the brain mechanically, turning and returning it without order or

* Varolius, p. 26.

† Ibid. p. 36. ‡ Ibid. p. 140.

method, going from the cerebellum to the optic and olfactory nerves, and from the optic and olfactory nerves coming back to the cerebellum. Let me add, that Varolius himself says, that the mass he calls spinal marrow is comprised between the annular protuberance and the cerebral hemispheres; and further, that he continually speaks of the spinal cord as a production of the brain. What the Committee of the French Institute make Varolius say, consequently, is not to be found in his works.

Let us now turn to and review the method of dissection practised by Vieussens, which, according to the Committee of the French Institute, is "*the same that Varolius employed, but with greater order and detail.*" In his first thirteen plates he shews nothing but sections of the brain from above downwards. He begins his demonstration with the convex part of the hemispheres, and then passes to the corpus callosum. The better to expose this, he cuts off the entire superimposed hemispheres by a horizontal sweep, and then by properly trimming the mass that is left, he forms, what he calls, the *centrum orale,* in which he concentrates all the medullary fibres that, according to him, arise from the cortical substance of the brain, and from which he makes nervous fibres descend to every part of the body. He then passes on to the transparent partition (valvula Vieussenii), that has since gone by his

name, to the fornix, to the choroid plexus, to the nates, to the testes, &c. &c.

"We have," he says, in one place expressly, "explained in a clear and complete manner, all that concerns the superior part of the brain and medulla oblongata; we have also examined the cerebellum externally and internally; we have only then, *following the order of dissection which we have adopted,* to examine what is found without and within the basis of the brain, properly so called, and the spinal marrow."

"After the exact explanation," he proceeds, "of all that is to be seen on the upper part of the brain and spinal marrow, or that belongs to the cerebellum, in order to find with ease, and to describe with care that which is found at the basis of the brain, properly so called, and of the spinal marrow, we take away the cerebellum by cutting its peduncles transversely, and turn over the brain, freed from its convex parts by partial sections, and then we show the divided trunks of the anterior arteries of the base of the brain—the ten pairs of nerves—the infundibulum—the two white prominences situated near the infundibulum—the two processes of the cerebellum towards the medulla oblongata, which run into the major annular protuberance of Willis—the pyramidal bodies—the olivary bodies—and the spinal nerves which join the par vagum."

It was always from his oval centre that Vieus-

sens began his sections and descriptions of the brain. His principles, indeed, did not permit him to follow any other method of demonstration.

In our answer to the Committee of the Institute, Dr. Gall and I have gone more deeply into details; but the passages cited above will suffice to shew that the methods of Varolius and Vieussens are directly opposed to our manner of dissecting and considering the brain and its parts. Vieussens, in deriving all the nervous fibres from his oval centre, proves himself to have had no idea of the successive reinforcement of the cerebral masses. I may, indeed, say generally, that an examination of all the anatomical works published before our time, and an inquiry into the various modes in which the brain has been dissected, whether in public or in private schools, will not fail to convince every candid mind that there is not even a hint at the anatomico-physiological views which we have given to the world. These views some modern anatomists have adopted, but we still advance our claim of right to be considered as the discoverers and introducers of a new method of dissecting the brain—as the first demonstrators of the anatomy of its masses in harmony with their physiology.

What, then, is our mode of investigating the structure of the various cerebral masses? I have already shewn (in the preceding section), that we consider the nerves commonly entitled cerebral,

as independent of each other, and that we regard the masses of the cerebellum, and brain, properly so called, as added to the nerves of the five senses and of voluntary motion. This point of doctrine established, we view the brain not as an unit or single organ, but as an assemblage of particular apparatuses destined to special and determinate functions, after the manner of the nerves of the external senses.

To this it may be said, that several anatomists have spoken of many peculiar parts, that they have even designated these by appropriate names, consequently, that our ideas on the plurality of apparatus are not new.

There is no doubt whatever, but that all anatomists have recognised distinct parts in the brain, and given them names according to their physical qualities. They have found hemispheres, convolutions, cavities, striated bodies, pea-shaped bodies, stalks or legs of the brain and cerebellum, writing pens, rams'-horns, semicircular tape-worms, pyramidal and olive-like bodies, &c., &c. Now we, in shewing that the individual masses, so named, do by no means constitute special apparatuses, performing peculiar functions, differ from all the anatomists who have gone before us. We were, also, the first to prove the relative proportions that exist between several of the cerebral masses, and to examine them in their mutual relations. If I continue to make use of the mechanical nomen-

clature, to speak of parts in particular, which can no longer be considered as special apparatuses, it is only for the sake of being more readily understood. My connected description will shew what masses I look upon as peculiar organs.

Our physiological views do not, it must be evident, allow us to go on cutting the brain into slices; this procedure, indeed, ought rather to be entitled a destruction, than an anatomical demonstration of the cerebral structure; it is precisely as though one should pretend to dissect a leg or an arm, by slicing down these members transversely, or to shew the structure of the thoracic and abdominal viscera, by treating the trunk in a similar manner, and giving names to the appearances exposed after each successive slice. We commence our dissection at the place where the proper cerebral masses are added to the nervous parts already described; we trace them in their continuations, and in their connexions mutually, and with the nerves of the five senses and of voluntary motion; in short, we proceed in the dissection of the brain in a manner precisely analogous to that which is followed in the anatomical demonstration of the other parts of the body.

Besides the above general anatomical principle as regards procedure, it is important to know that on account of their extremely delicate organization, the structure of several cerebral parts may

be more easily and clearly exposed by means of scraping than by cutting. This is the reason why I frequently prefer the handle to the blade of the scalpel for removing parts that cover those whose course I would shew,—for instance, the passage of the pyramidal bodies across the annular protuberance—the continuation of the anterior commissure through the striated bodies into the middle lobes of the brain, and of the anterior pillars of the fornix, onwards to the mammillary bodies and interior of the thalami.

The brain should be removed from the cranium, care being taken not to tear the crura at the superior edge of the annular protuberance, (an accident that is very apt to occur,) nor to injure the medulla oblongata at the lower edge of the same part, and to cut the spinal mass so low down as to obtain, besides the entire medulla oblongata, the upper part of the true spinal cord. The brain thus freed from the skull, is then to be put into a plate, with the basis uppermost. The cerebellum and medulla oblongata having lost the support of the bone, now fall backwards. (Pl. vii. fig. 1.) In this position, all the appearances presented by the base of the brain are visible. Having considered the cranial nerves in the manner described in the preceding section, the structure of the true cerebral masses is to be examined, commencing with that of the cerebel-

lum. As I treat of the several parts, I shall always indicate the procedure that appears to me the most convenient for exhibiting their anatomy*.

* The method of dissecting the brain which M. Laurencet of Lyons proposes, seems founded on imaginary notions, rather than on the observance of nature and fact. According to him, the nervous system is like two trees reversed, the branches of the one being continuous with the roots of the other, or after the manner of the sanguiferous system. The spinal cord, he says, consists of four bundles, which, in the medulla oblongata, are the anterior and posterior pyramids. The anterior, after their decussation, he supposes to continue across the pons Varolii, the crura cerebri and corpora striata, towards the corpus callosum and the convolutions, from thence to the fornix, to the thalami, corpora quadrigemina, cerebellum and posterior pyramids. The number of nervous fibres is assumed to be everywhere the same; there are only bulgings and contractions in succession. M. Laurencet cuts the parts, and then tells us how they are formed.

Section V.

Of the Cerebellum.

To avoid all risk of confusion, I repeat once more that I separate the nervous mass of the spine and the cranial nerves from the brain, and that I confine this last appellation to the entire nervous mass, added to the nerves of the external senses and of voluntary motion. I also repeat that the first anatomical principle of the nervous system, generally, applies to the brain in particular, that is to say, this mass is not a simple unit, but a collection of many peculiar instruments. As this proposition is of great importance, I shall examine it here at some length. It is to be established by anatomy, physiology, and pathology. The physiological and pathological proofs of its truth, are contained in the second section of my Work on Phrenology, wherein I treat of the plurality of the organs. In this place, consequently, I shall confine myself to illustrative anatomical considerations.

That the cerebral parts are more or less numerous in different tribes of animals, is a fact which cannot be gainsaid. Many writers, among others, Dr. Gall*, say that *the faculties of animals are*

* Anat. et Phys. du Cerveau, t. iii. p. 364.

multiplied in proportion as their brains are complicated. Were this remark universally correct, it would serve as a positive proof of the brain's being an assemblage of organs. But without reckoning the difficulty, not to say the impossibility of determining, anatomically, even in birds and mammiferous animals, the constituent parts of the brain, and admitting that as true which mechanical anatomy demonstrates, *viz.*:—that the brain is made up of a greater or smaller number of bundles, it must still be observed that each particular bundle cannot, legitimately, be assumed as composing a peculiar organ. There are several cerebral masses which, although more or less compound, do not, therefore, cease to be mere units. Take the cerebellum as an example. This is extremely simple in fishes, and very complicated in man, nevertheless it is but a single instrument in both. The same law applies to several other cerebral parts, which, although exceedingly complex, only compose the instrument of a single function. Thus the first fact showing the structure to be more or less complicated, is no satisfactory or conclusive evidence as to the plurality of the cerebral organs—this induction is still only problematical.

Dr. Gall derives another anatomical proof of the principle under discussion, from the analogy that subsists between the organization of the brain and that of the other nervous systems. This analogy, however, is very limited. The

spinal cord affords no example of it. Although composed of many parts, or numerous pairs of nerves, its functions are but repetitions of two of different kinds: *viz.*, sensation and motion. But the particular organs of the brain must be as distinct as the acoustic, optic, and olfactory nerves.

A better anatomical illustration follows from the fact of all parts of the brain not being developed simultaneously, and of their volumes severally bearing no regular proportion to each other. The size of the cerebellum, for instance, is not in any direct ratio to that of the brain, neither are the three lobes of the cerebral hemispheres proportionate to each other. The same law applies in regard to all the individual parts of these lobes.

These proofs, founded on the non-simultaneous development and non-proportionate volume of the individual portions of the encephalon, are strengthened by facts, which shew that the cerebral parts may severally be wanting. M. Jadelot was so kind as to shew Dr. Gall and me an hydrocephalic child, in the *Hôpital des Enfants Malades,* at Paris, many of the superior convolutions of both hemispheres of whose brain were wanting, so that there was a hole communicating on each side with the lateral ventricles. The edges of these holes were smooth, and all the appearances bespoke a congenate or primary de-

fect of organization. The brain, of which a drawing is given in pl. v. fig. 5 and 6, belonged to a girl, who died, aged seventeen, and was idiotic from birth. She died in the asylum at Cork. Dr. Abell, of that town, and Dr. Cheyne, of Dublin, had the goodness to send me the natural skull, and casts, in plaster, of the brain and bust. A comparison of this brain with one of a healthy and well-constituted individual (pl. vi. fig. 1 and 2), will show its anterior lobes to be exceedingly deficient, and the convolutions that commonly exist in the upper region of the forehead to be wanting altogether. It is even less complicated, and more poorly developed, especially anteriorly, than the brain of the ourang-outang. (Pl. v. fig. 3 and 4.) Mr. Stanley, of London, preserves a similar idiotic brain in spirits.

The anatomical evidence, from the want of proportion among, and the non-simultaneous development and entire absence of, the cerebral parts, although plausible, is not, however, decisive in proving the plurality of the organs. The testimony these facts supply only becomes conclusive, when they are united to physiology. Alone, they do not prove that the functions of the parts, whose development is neither simultaneous nor proportionate, and which, individually, may be wanting, are dissimilar.—The branches of a tree shoot in succession, yet all bear the

same [fruit. But those cerebral parts are indubitably the same, however dissimilar in physical appearance, if like functions appear with their presence, increase with their growth, are vigorous in proportion to their masses, and wanting with their absence. Cerebral parts, on the other hand, differ if like functions do not appear with their development, be not manifested in vigour corresponding to their volumes, and exist or not independently of their presence or absence.

Certain it is, therefore, that how important soever it may be to classify the cerebral organs, anatomy alone would never enable us to attain such a consummation. The aid of physiology is indispensably requisite. Now Dr. Gall and I claim the merit of having been the first to compare the relations between the development of different cerebral parts and peculiar functions; and our physiological anatomy of the brain proves, that the parts indicated in books of descriptive anatomy as distinct masses, such, for instance, as those styled pons or bridge, pyramidal and olive-like bodies, thalami, mammillary bodies, callous or hard body, &c. &c., do not constitute particular organs.

Some anatomists have expressed doubts as to the possibility of proving the presence or absence of individual parts in the human brain, especially in the hemispheres and their convolutions; because, say they, the physical appear-

ance of these is not invariable. But, provided essentials be not confounded with modifications, the very reverse of the above assumption may easily be proved. The lobes are always to be distinguished from one another, and certain convolutions from others, with the same certainty as the annular protuberance is to be discriminated from the crura of the brain, the quadrigeminal from the mammillary, and the pyramidal from the restiform or olive-like bodies. The general form and direction of the convolutions, even of the human brain in its complication, are, in fact, remarkably regular. Thus, the transverse convolutions of the superior lateral and middle parts of the hemispheres are never found running in any other direction, never longitudinally for example. Those that lie longitudinally again, as they do under the squamous suture, behind the temporal bone, and on either side of the olfactory nerve, are never met with disposed transversely.

" Shew Gall," says Dr. Rudolphi *, " the organs of theft, of murder, and of the religious sentiment separated from the cerebral mass, and be sure he would not know them." Dr. Gall †, in his reply to this, contents himself with saying, " Shew M. Rudolphi morsels of the spinal

* Physiologie, ii. Band, Berlin, 1823.

† Sur les Fonctions du Cerveau, tom. vi. p. 138.

marrow or medulla oblongata, and be sure he would not know them; yet are the spinal marrow and medulla oblongata proved to be aggregates of different nerves." This answer of Dr. Gall does not satisfy me. In the first place, I have shewn the brain to be composed of many parts, whose functions are essentially different, whilst all the portions of the spinal cord have similar offices. Dr. Gall's reply, therefore, is simply evasive. But, for my part, I will accept M. Rudolphi's proposition directly; for I maintain that he who has studied the forms of the peripheral expansions of the cerebral organs, will always be able to distinguish, in man, the organ of acquisitivenes from that of destructiveness, and that of veneration from either, (the organs of theft, murder, and the sentiment of religion, in M. Rudolphi's nomenclature,) as easily as an ordinary observer will the olfactory from the optic nerve. I am ready at any time, personally, to verify the above statement.

However, I still admit, that the convolutions forming parts of any particular apparatus, present many modifications in reference to size and number of anfractuosities. Such modifications occur, not only in the brains of different individuals, but even in the two hemispheres of the same brain. Variety, however, need not be confounded with essential configuration. I have

remarked, that the organs which are best nourished, and most largely developed, have generally the smallest number of anfractuosities.

The importance of classing the cerebral organs is, as I have said, evident. Researches to this end interest the anatomist, the physiologist, and, above all, the practical physician, on account of the brain's influence on the vegetative functions, on the origin, duration, character, and cure of a long list of diseases, especially of such as depend on moral causes. To render such inquiries complete, they must be extended into comparative anatomy, always in the view of proving the brain to be an assemblage of organs, destined to dissimilar functions, mutually in relation, liable to disease severally, and likewise to derange each other reciprocally.

To compare the spinal cord, and even the cranial nerves, in the different classes of vertebral animals, is by no means a very arduous task. But to do the like in regard to the brain is one of extreme difficulty. Anatomists commonly set out with the human brain in their eye as a type of comparison; this they consider as an unit having two hemispheres, a corpus callosum, an anterior, middle, and posterior commissure, an infundibulum, fornix, feet of a hippocampus, mammillary bodies, striated bodies, optic thalami, a semicircular tenia or tape-worm, quadrigeminal bodies, crura or legs, a valve of Vieus-

sens, a pons, bridge, or annular protuberance, a cerebellum, having also crura or legs, a medulla oblongata, pyramidal, olivary, and restiform bodies, four ventricles, an aqueduct styled of Sylvius, and several other parts: and then they proceed to recognise or deny the existence of parts according to mere physical appearances, especially forms and situations.

Such a mode of proceeding, however, is quite inadequate to establish a system of comparative cerebral anatomy. The brain, in the first place, is not an unit, but an assemblage of particular apparatuses, that require severally to be specified; and again, it is certain that the isolated masses, such as they are described in books of anatomy, do not constitute peculiar organs, but that several of them, indeed, sometimes go to the formation of one. The cerebellum is found, either with or without an annular protuberance; the anterior pyramidal bodies are not one organ, but consist of parts of many; they are, in fact, the rudiments of the organs of the intellectual faculties. And further, the physical appearance of apparatuses which are known to have analogous functions, is often exceedingly different. Without knowing the functions of the cerebral parts, it is, therefore, impossible to demonstrate either their identity or their difference. What anatomist, unacquainted with the function of smell, would ever have concluded that the olfactory nerves of the skate,

flounder, chicken, seal, ox, and man, were analogous masses? Certainly, similarity of appearance would never have led to the conclusion; and differences in appearance among the other cerebral masses, are not less remarkable than in the olfactory nerve throughout the four classes of vertebral animals. Thus, I conceive that the comparative anatomy of the brain can neither be itself ad vanced, nor afford satisfactory conclusions without the aid of physiology.

The common and objectionable manner of examining the structure of the encephalon, led anatomists to conclude that they had discovered the same cerebral masses in the mammalia as in man, and, because the forms of the parts were different, to deny their existence in birds and the inferior classes of animals. In all the lower tribes of creation, they supposed another and a different composition of the encephalon.

I claim the merit of having been the first to maintain that the analogy or difference of cerebral parts, in different classes, ought to be determined by the combined aid of anatomy and physiology. I have no hesitation in saying that the relations of the cerebral masses, as they are indicated by M. Serres in his prize memoir, are very far from having replied in a satisfactory manner to the question proposed by the Institute of France. I also think it may not be out of place to state that Baron Cuvier, perpetual secretary to

the physical class of the French Institute, in his analysis of the academy's labours for the year 1820, has mentioned the name of Dr. Gall in reference to two points only, on which M. Serres differs with the Doctor, whilst he reports several other and important facts and views, discovered by me, and published conjointly with Dr. Gall, as forming part of the memoir of M. Serres; such, for instance, as the relation between the annular protuberance and the lateral parts of the cerebellum, and that between the corpus callosum and the cerebral hemispheres.

In admitting as an anatomico-physiological principle, that the particular organs of the cerebral functions bear no proportion relatively, in the same way as the instruments of the external senses are in no direct ratio one to another, I deny generally, as I have already done particularly, in regard to the spinal cord, the proposition of M. Serres, according to which, "*the tubercula quadrigemina serve as a basis of determination to the other parts of the encephalon* *." The quadrigeminal bodies do, in nowise, bear any direct proportion to the anterior, middle, and posterior lobes of the brain. These masses exist independently of each other, and belong to apparatuses that are totally distinct. The quadrigeminal tubercles are

* "Les tubercules quadrigeminaux servent de base de determination aux autres parties de l'Encephale," *Rapport*, &c., p. 67; and *Serres's Anatomie*, &c. vol. 1, Preface.

absolutely smaller in man and the dog, than in the horse and ox, but the brain of the animals last mentioned is larger than that of the dog, and smaller than that of man. Each special apparatus must be determined by itself, and by comparison with its particular function.

In many fishes there are portions of gray nervous substance to be observed, forming ganglions on the lateral edges of the medulla oblongata. (Pl. ii. fig. 3, 5, 12, 13, *e*.) By removing the cerebellum, a ganglion may, in many species, be seen in the middle line (pl. ii. fig. 13, 43); this ganglion is, sometimes, naturally exposed. (Pl. ii. fig. 5, 43). All these masses pertain to the nerves that issue from them.

The nervous mass immediately succeeding these ganglia, is the first cerebral apparatus; it is distinguished by the name of cerebellum, and exists in all vertebral animals lying on the dorsal surface of the medulla oblongata. Its name is derived from the anatomy of man, in whom the corresponding mass is smaller than the brain, properly so called. This example, among many others that might be cited, proves how defective that nomenclature of the encephalon is, which is founded on the physical qualities of the human brain. Is it not astonishing that anatomists, who deny to fishes a cereberum or brain, should still acknowledge them possessed of a cerebellum or little brain? Let me, therefore, repeat, that a good nomenclature should have for its basis the nature of the

functions performed by the particular instruments. My only reasons, as I have said already, for continuing to use the old and faulty names, is to make myself understood more readily.

The cerebellum or organ of amativeness, is complicated in different degrees in the four classes of vertebral animals; its form and its volume vary exceedingly, but it regularly communicates posteriorly with the nervous mass of the spine on either side, and anteriorly with the bigeminal or quadrigeminal bodies.

"To acquire accurate notions of the cerebellum in the superior classes," says M. Cuvier, "according to M. Serres, they must, in the first instance, be taken from fishes. In these animals, this organ is formed of two very distinct parts—a middle lobule deriving its roots from the ventricle of the quadrigeminal tubercles, and two lateral portions coming from the restiform bodies; the two parts are insolated and disjunct in the whole of the class pisces, a circumstance that has occasioned them to be mistaken*."

Now this fact is not, by any means, so general

* "Pour avoir des notions exactes sur les cervelets des classes supérieures d'après le Mémoire de M. Serres, il faut d'abord les emprunter aux poissons.—Chez les poissons cet organe est formé de deux parties très distinctes: d'un lobule median, prenant ses racines dans le ventricule des tubercules quadrigeminaux, et de feuillets lateraux provenant du corps restiforme: les deux parties sont isolées, disjointes dans toute la classe des poissons ce qui les avait fait méconnaitre."—*Rapport des Travaux de la Classe Physique pendant l'Année* 1820, p. 67.

as M. Serres would have us suppose. What are his reasons, let me ask, in the first place, for classing the ganglion I have just pointed out as situated in the fourth ventricle (pl. ii. fig. 5 and 13, 43), along with the cerebellum?—He can have none. And again, in the eel (pl. ii. fig. 1)—in the cod (pl. ii. fig. 2)—in the flounder (pl. ii. fig. 7)—in the roach (ib. fig. 11), and many others, the surface of the cerebellum is quite smooth. In the skate, on the contrary, it is evidently composed of several ramifications. (Pl. ii. fig. 3.)

In fishes, generally, there is a bundle which, with its fellow of the opposite side, forms a hollow mass stretched above the fourth ventricle, and covered on its peripheral surface with gray substance. It is, for the most part, loose at one extremity only; it has either a pointed, a rounded, or a flattened form, and is most commonly turned towards the back. In the skate, however, it has two loose extremities, the one pointing forwards, the other backwards.

Reptiles, in general, have a cerebellum, composed of two parts, which are hollow, superficially smooth, and in communication with each side of the medulla oblongata. In some of the class, it is extremely small, as in the toad and frog (pl. iii. fig. 2), which, in this respect, resemble the sturgeon among fishes; in other reptiles, however, and of the number is the crocodile, the cerebellum, as in the skate and shark, is furrowed on the

surface, and bears marks of a more complicated structure.

The ramified and lamellar structure of the cerebellum (pl. iii. fig. 5, 6, 7, 9, 10, and 11), and its division into median and lateral portions, become very evident and regular in birds and mammiferous animals. In birds (pl. iii. fig. 5, 7, 10, and 11), the middle or primary portion is large compared with the lateral parts. These, indeed, are scarcely evolved in the class aves, they, however, become ever more remarkable in size and number of ramifications, in proportion as we mount from the lowest up to the highest of the mammiferous tribes and reach man. In the fœtus, the cerebellum, even of those animals in which it afterwards presents numerous convolutions, is always quite smooth. The primary portion of the cerebellum, in all birds, is divided into several branches; the middle and upper one of these is the most remarkable. Below and in front of the fourth ventricle, in the same class, there occurs a little lobule, the volume of which, like that of the lateral parts, is much augmented in the mammalia. These peculiarities of structure prove that oviparous animals, in general, cannot be said to have a simple cerebellum.

The cerebellum of fishes, of reptiles, and of birds (pl. xi. fig. 3, 62), is constantly hollow. Its cavity communicates with the fourth ventricle (*ib. m*), or space between the cerebellum and

medulla oblongata. The cerebellum of the mammalia is, on the other hand, invariably solid; the fourth ventricle is the only cavity in its vicinity. (Pl. xi. fig. 1, *m.*)

The anatomical principle laid down in regard to the regularity of proportion, between the cineritious and white substances, and to the occurrence of cineritious matter at the origins of nervous masses, is confirmed by the structure of the cerebellum. At the place of this organ's attachment to the medulla oblongata, there is always an accumulation of pulpy substance to a greater or smaller amount; that is to say, the quantity is great, or small, relatively to the volume of the entire cerebellum. In man it composes an irregularly-shaped mass, toothed or serrated around the edges. This collection of cineritious intermixed with white matter, is described in books of anatomy under various names, such as corpus rhomboideum, corpus dentatum, zig-zag, and kernel of the cerebellum. I speak of it under the title of ganglion of the cerebellum.

Vicq d'Azyr believed that the ganglion of the cerebellum was only to be found in the human kind. But in 1808, conjointly with Dr. Gall, I shewed that it exists in the mammalia generally *; and I now add, that it is very distinct in birds. Whenever the cerebellum is somewhat considerable, it may always be demonstrated. Its

* Vid Mémoire sur l'Anatomie du Cerveau, &c.

small size and pale colour were probably the causes of its existence being overlooked. But it is matter of prime importance not to confound the forms assumed, and the lighter or deeper shades of colour possessed by the pulpy substance, with its necessary existence.

The quantity of cineritious substance at the origin of the cerebellum is in the direct ratio of the entire mass, and not merely of the lateral parts of that organ. It is very conspicuous in birds, although the lateral parts of their cerebella be but rudimentary. In man too, a portion of the ganglion may easily be demonstrated running towards the vermiform process (the primary part) of the cerebellum.

From what I have said, it follows that this ganglion is not situated in the middle of the cerebellum, but commences where this mass is connected with the medulla oblongata. Vicq d'Azyr commits a capital error in his plate xxxi. fig. 20, in representing the ganglion of the cerebellum as placed so much externally, so near to the anterior edge of the organ to which it belongs, and so far distant from the medulla oblongata.

In forming the cerebellum, nature has, in all animals, pursued the same plan. Two bundles constantly bring it into connexion with the two sides of the medulla oblongata; these are of variable size; they meet a greater or smaller quan-

tity of gray substance, and proceed strengthened in proportion to the quantity of this substance encountered; they then regularly compose a primary portion, which in the lowest tribes is smooth superficially, but which, as the scale is mounted in, appears furrowed transversely, or divided into lamellæ, and gets complicated by the addition of lateral masses, laminated in like manner. This lamellar structure is exposed by a vertical cut through the cerebellum; it bears the name of arbor vitæ, on account of its supposed resemblance to the foliage of the thuya, or tree of life. (Pl. viii. and ix. fig. 1 and 2.)

Although the human cerebellum be very complicated, the elements of a precisely similar formation to that of the lower animals, may without difficulty be traced. One slip from the ganglion forms with its fellow of the opposite side the vermiform process, or primary portion, which by a cut carried through the middle line, may be seen afterwards dividing commonly into seven principal parts. (Pl. vii. fig. 2, and pl. x. fig. 1, and pl. xi. fig. 1. A.) These divide into branches, and these again into leafets, differing in each case in number, length, and volume generally.

The other slips or bundles that issue from the ganglion proceed backwards, upwards, downwards, and outwards, and expand into layers, which are disposed horizontally. Those that come from the middle of the ganglion are the

longest, the others are successively shorter as they issue nearer to the commencement of the ganglion. (Pl. viii. fig. 1, pl. ix. 1 and 2, and pl. xi. fig. 1, B.)

The peripheral extremities of the bundles thus disposed in lamellæ, are, as well as when they expand and form an uninterruptedly smooth surface, covered with a layer of cineritious substance.

By a section carried vertically through the middle of the ganglion in the direction of its bundles, eleven principal trunks or branches are commonly exposed. The nearer the cut runs to the middle, or posterior edges, of the cerebellar hemispheres, the greater will be the number of branches discovered, as their quantity will be fewer in proportion as it passes nearer to the mesial line of the body. Two branches may frequently be seen intimately united near the base of the ganglion (pl. ix. fig. 2, and pl. xi. fig. 1. B.), and forming, for some little way, a common stalk; but in other cases they proceed quite distinctly from the very beginning. Still greater varieties are to be detected in the interior divisions and subdivisions, which are unimportant, and require no particular mention.

The ganglion of the cerebellum varies considerably in form, and this, not only in different species, but even in different individuals of the same kind of animals. Its appearance

also changes according to the mode in which it is cut; horizontally incised, it has the figure expressed in pl. viii. fig. 2, B. *s.*; obliquely, the form represented in pl. xi. fig. 1, B. *s.*; and, vertically, the contour given in pl. viii. fig. 1, and pl. ix. fig. 1 and 2 *s.* A horizontal cut shews it in its greatest extent.

Although the portions or ramifications of the cerebellum be divided into parallel lamellæ, they do not ultimately lie parallel to each other; each portion thus considered is placed obliquely. Neither are the furrows on the outer surface parallel. (Pl. vi. fig. 1 and 2. Pl. viii. fig. 1, B.) Sœmmerring has remarked, and exposed the error generally committed by anatomists in this matter in their drawings. It is also a mistake to suppose, that the furrows of the cerebellum penetrate deeply into its substance. They only do so in the clefts that mark its principal divisions.

In the mammiferous class of animals the cerebellum is augmented by the addition of a mass, known variously by the names pons Varolii, tuber annulare, or mesolobe. The transverse fibres of this part evidently belong to the hemispheres or lateral portions of the cerebellum, to which they bear a marked and regular proportion. (Pl. viii. fig. 2.) No one can deny to Dr. Gall and me the merit of having first detected the relations that exist between the annular protuberance and cerebellar hemispheres. M. Tiede-

mann * says, that we err in deriving the transverse fibres of the annular protuberance from the cineritious substance covering the leafets of the cerebellum, because these transverse fibres are visible before any division into lamellæ can be recognised in the cerebellum. This reasoning of M. Tiedemann, however, does not seem very conclusive, since the annular protuberance and cerebellum are developed at the same time. It is, on the other hand, at least certain, that M. Tiedemann is himself mistaken, in supposing the transverse fibres of the annular protuberance to come in part from the corpus dentatum (ganglion of the cerebellum.) † The annular protuberance lies most evidently anteriorly and quite externally to the ganglion of the cerebellum; its fibres, moreover, may easily be demonstrated, as commencing directly from the lamellæ of the hemispheres. (Pl. viii. fig. 2.)

I, for my part, insist rather on the progressive augmentation of the cerebellum in the different classes of animals, than on the successive increase of its individual constituent parts. It appears certain, that the several parts of the cerebellum are not simultaneously developed; that some of these are visible at an earlier period than others, But it still remains a point of great dif-

* Anatomie du Cerveau dans le Fœtus Humain, Nürnberg, 1816.

† Op. cit. p. 107.

ficulty to determine the part which serves as the centre of departure or originator of the others. Are the various portions developed after the manner of the graft of a fruit-tree, or are there branches thrown off in succession, or, are the rudiments of the whole called into a being at once, and maturity of growth then acquired by each in succession? The first supposition, I confess, appears the most probable to myself. It is not unreasonable also to presume, that the fibres of communication, and the fibres of the commissures, or apparatuses of union, appear together, whilst the peculiar apparatus which is to perform a special function, acquires the form, volume, and organic condition necessary to this duty by degrees.

Although the cerebellum be ever more complicated as we ascend in the scale of beings, it is a fact, that animals do not exhibit faculties in proportion as this mass presents a larger number of lamellæ or ramifications. Neither is it found that the intellectual and other general mental powers of individuals of the human kind increase, or are active in the ratio of the cerebellar lamellæ, as was once maintained by Malacarne.

Many authors have said, that the cerebellum contained, in proportion to its bulk, more cineritious substance than the brain, and as a consequence of this notion, it came to be regarded as

softer than the brain. Both of these assumptions are incorrect. The primary mistake was probably committed from vertical sections having always been employed to expose the internal structure, *i. e.*, the arbor vitæ of the cerebellum, whilst horizontal slicing was the method followed in regard to the brain. But let an opposite procedure be adopted; let the cerebellum be trenched horizontally, and the brain vertically, and, for certain, more cineritious substance will then appear in the brain than in the cerebellum. The cerebral convolutions again, it is natural to think, will, on account of their mere thickness, seem firmer than the cerebellar leafets; but careful examination proves that in one case the brain, and in another the cerebellum, possesses the greatest degree of consistency. Age and fortuitious circumstances, as disease, &c., exert a particular influence in this respect.

From what has been said when discussing the nerves of the external senses and voluntary motion, it may almost be unnecessary here to state, that none of them arises from the cerebellum.

All the parts of the cerebellum are double, or exist in pairs; its primary portion or vermiform process, is no exception to the law; all its parts, however, are not necessarily symmetrical; the elements composing each side are alike, but the size of the essential bundles, the length and thickness of their branches, the number of sub-

divisions of these, and the form and lie of the lamellæ vary extremely in different individuals, and often on both sides of the same cerebellum, the entire mass of one side being not unfrequently more largely developed than that of the other.

In their descriptions of the cerebellum, anatomists still make mention of two soft and thin layers, the one of which unites the upper part of the posterior pyramidal bodies with the lower portion of the vermiform process (the primary or essential mass), whilst the other brings the cerebellum into connexion with the quadrigeminal tubercles. The latter is commonly known by the name of the valve of Vieussens, or by the singular title of *processus à cerebello ad testes.* (Pl. xi. fig. 1 and 3. *y.*) Reil styles them the superior and inferior medullary veils.

The valve of Vieussens, or layer of communication between the primary portion of the cebellum and quadrigeminal tubercles, may be distinctly traced through all the four classes of vertebral animals. It increases in size in the ratio of the distance and nervous masses, between the cerebellum and quadrigeminal tubercles. The inferior veil, on the contrary, is but just apparent in birds; in the mammalia, however, like the superior, it is conspicuous, although varying in size in the different species composing the class.

The idea of a determinate proportion between the brain and cerebellum is one still very gene-

rally entertained. Authors on the comparative anatomy of the brain have even drawn up tables of this supposed proportion. "It is easy," says M. Cuvier*, "to ascertain the proportionate weight of the brain and cerebellum, because no variation in health, and no change in the bodily condition, as to obesity or leanness, exert any influence on them." But it is long since Dr. Gall and I shewed, that the cerebellum has no regular proportion to the brain. In the adult a small cerebellum is often met conjoined with a very large brain, and in other cases the cerebellum occurs of great size, while the brain is particularly small. M. Chaussier has also observed, that the cerebellum composed at one time the sixth, at another the seventh, and at another, and more rarely, the tenth of the weight of the encephalon. In newly-born infants, he found that it was the thirteenth, the fourteenth, the seventeenth, and, in one instance, no more than the thirtieth part, by weight, of the encephalon. Whoever, indeed, will be at the pains to compare the encephalon of children of two, four, six, and ten, and of young people up to their sixteenth year, will be convinced, that relatively to the brain the cerebellum is at these periods smaller than in adult age. If any exception to the rule be found, it must be regarded as an individual peculiarity of organization. Moreover,

* Leçon's d'Anatomie Comparée, vol. ii. p. 152.

the cerebellum is generally larger in men than in women, and in males than in females of the same kind of animal.

Let us now examine some points of M. Serres's Prize Memoir, in relation to the cerebellum.

He says *, " it may appear singular, that the cerebellum should not be formed till after the quadrigeminal tubercles; nevertheless, there is no exception to this fact in any class."

Now this fact will *not appear singular*, but seem perfectly natural to those who are acquainted with the functions of the apparatus that arises from the quadrigeminal bodies, and with the office of the cerebellum. As the optic nerve has to act long before the cerebellum, its organization requires to be complete long before that of the cerebellum needs to be perfect. Further, the brain is also developed at a later period than the quadrigeminal bodies, the cerebellum consequently presents nothing whatever that is singular in this respect.

" The vermiform process," says M. Serres in another place †, " comes from the quadrigeminal tubercles, whilst the other part, issuing from the restiform bodies, constitutes the hemispheres of the cerebellum. The two elements of the cerebellum, (the vermiform process and lateral parts,) also, though united, are still entirely independent of each other."

* Rapport de l'Institut, 1820, p. 68.

† Ibid. p. 68.

These propositions do not to me seem founded in nature. Were we to admit the bigeminal bodies of fishes and reptiles, and the quadrigeminal tubercles of the mammalia, as the source of the vermiform process, or primary portion of the cerebellum, we should then expect some regular proportion in the development of these parts to each other. But M. Serres himself excepts reptiles. " In all the classes except that of reptiles," he says *, " the median lobe of the cerebellum (*processus vermiculaire supérieur,*) is developed in the direct ratio of the quadrigeminal bodies." Now this exception is of itself sufficient to refute M. Serres's entire assumption. However, let the cerebellum be compared with the optic tubercles in the sturgeon, in the eel (pl. ii. fig. 1), flounder (pl. ii. fig. 4), skate (pl. ii. fig. 3), barbel (pl. ii. fig. 12), pigeon, turkey, dog, and other animals, to procure data, by which to estimate the utter erroneousness of M. Serres's opinions. On dissecting the cerebellum of mammiferous animals, the vermiform process, as well as the other ramifications, generally, will be seen communicating distinctly with the dentated body, or ganglion of this organ. Lastly, and still further, to expose this error relative to the origin of the primary portion of the cerebellum, let us recur to pathological anatomy, as well to the cases produced accidentally or by disease, as to

* Rapport de l'Institut, 1820. p. 68.

those created intentionally, or by mutilations. Atrophy of the optic nerves, caused in any way, is well known to extend to the anterior pair of quadrigeminal bodies; no one, however, has yet imagined that it was continued on to the median lobe, or primary portion of the cerebellum. The optic tubercles and the vermiform process, therefore, exist independently of each other; they are connected, only that they may exert a mutual influence.

It is not the same in regard to the median lobe and the lateral parts of the cerebellum. True it is, that these two masses are not necessarily proportionate to each other; this fact, however, does not prove each entirely independent of the other, as M. Serres has presumed *. I take his own manner of viewing the matter in illustration: he regards the bigeminal tubercles of birds, reptiles, and fishes, and the quadrigeminal bodies of the mammalia and man, as essentially analogous masses; the quadrigeminal appearance in mammiferous tribes, he conceives to arise from a transverse furrow, which, in the human kind, commonly passes across the middle of the mass, which, in the carnivora, runs more anteriorly, and in the ruminantia and rodentia, passes more posteriorly, and thus makes the two pairs of tubercles appear of nearly equal size, or causes the front or back pair to predominate †. The two pairs of

* Rapport, &c. p. 66. † Ibid. p. 68.

tubercles, therefore, vary in proportionate size in the different tribes of mammiferous animals, precisely as do the median and lateral lobes of the cerebellum. Now if, according to M. Serres, the dissimilar development of the different pairs of the quadrigeminal bodies does not prove their independence, I do not see that it is reasonable to regard diversity of development of the median and lateral lobes of the cerebellum as any proof of their independence.

M. Serres thinks that the spinal cord, the median lobe of the cerebellum, and the quadrigeminal tubercles are developed in the direct ratio of each other, and in the inverse ratio of the cerebellar hemispheres and annular protuberance.

I have said that M. Serres himself excepts the class of reptiles from this law, and I have added other facts which refute his opinion regarding the dependence of the median cerebellar lobe on the quadrigeminal bodies. I have also shewn above, that the direct ratio of development which M. Serres recognises between the spinal cord and the quadrigeminal tubercles has no foundation in nature. An appeal to the same authority also proves that M. Serres deceives himself, when he fancies the spinal cord, the median cerebellar lobe, and the quadrigeminal tubercles to be developed inversely as the lateral parts of the cerebellum and annular protuberance. For in fishes, reptiles, and birds, there are no cerebellar

hemispheres, and no annular protuberance. The lateral parts of the cerebellum and annular protuberance are, in fact, developed in a greater or less degree in different tribes, but never inversely as the optic tubercles and spinal cord are concerned. The flounder (pl. ii. fig. 7), and carp (pl. ii. fig. 5), have optic tubercles of greater size than the eel (pl. ii. fig. 1), which of the three kinds, however, has the most voluminous spinal cord.

M. Serres also notices several relations between the annular protuberance and different other cerebral parts. Dr. Gall and I were the first who shewed the development of the annular protuberance in the direct ratio of the cerebellar hemispheres. No other one of the relations, mentioned by M. Serres, is constant; and, consequently, no other can be laid down as a law. The annular protuberance, for instance, is not regularly developed in the inverse ratio of the cerebellar median lobe, of the quadrigeminal tubercles, and spinal cord, as M. Serres pretends *. The annular protuberance, in general, is relatively less considerable in women than in men, but the spinal cord is not developed in an inverse ratio in the two sexes. I shall expose another of M. Serres's errors, in supposing the annular protuberance to bear a directly proportionate development to the

* Rapport, &c., p. 69.

corpus callosum†, when I come to speak of the last-named cerebral mass.

The advantage, it seems to me, would be little commensurate with the labour of ascertaining all the modifications presented by the cerebella of different animals, and of giving titles to every lobule superadded to the primary or median portion. Such inquiries appear to me the rather superfluous, as I view the entire cerebellum in the light of a single organ or apparatus, and as performing only one species of function.

I have still to add, that the cerebellum, like every other organ, is not only more or less complex in the different kinds of animals, but also that its several constituent parts are modified in the various individuals of the same species. The organ too, I may here observe, is developed at rather a late period of life, a fact which I have already had occasion to cite, in shewing that there was no regularity of proportion between the brain and cerebellum; I, however, call my readers' attention to the phenomenon, at present, in order that he may understand the tardy appearance of the function of the part (the sexual appetite). For the sake of physiology, I also adduce in this place, the fact of the larger size, generally, of the cerebellum in men and males, than in women and females of the several kinds.

* Rapport, &c., p. 72.

The cerebellum, then, is an apparatus of a structure, more or less complicated in different species of animals, having a greater or smaller development in the two sexes, and in different individuals of the same kind, and being in direct communication with the medulla oblongata and quadrigeminal tubercles.

To obtain as clear and comprehensive ideas of the position and external and internal structure of the cerebellum, as possible, I request my reader to turn to, and peruse the plates in the order as follows:—

For differences of form, of volume, and of superficial structure, see pl. ii. figs. 1, 2, 5, 7, 10, 11, 12; pl. iii. figs. 2, 3, 4, 5, 7, 10, and 11; pl. iv. figs. 1, 3, 5, and 6; pl. v. figs. 3, 4, 5, and 6; pl. vi. figs. 1 and 2. For the appearances and connections in the median line, examine pl. viii. fig. 2.

In oviparous animals, the cerebellum is hollow, as is seen in pl. xi. fig. 3, 62. In the mammalia and man it is solid; in them, there is nothing that can be likened to a cavity, except the separation between its primary portion and the medulla oblongata, or rather the posterior part of the annular protuberance; see pl. vii. fig. 2, *m*; and pl. xi. fig. 1, *m*.

The disposition of the cerebellar ramifications, from birds up to man, is lamellar, as it is presented in pl. iii. fig. 1; pl. viii. fig. 1 and 2; pl. ix. fig. 1 and 2; and pl. xi. figs. 1, 3.

For the appearance and structure of the cerebellar commissure (annular protuberance,) inspect pl. iv. fig. 2; pl. v. figs. 3 and 5; pl. vi. fig. 11, 2; and pl. viii. figs. 1 and 2.

The ganglion of the cerebellum (dentated body) is represented in pl. viii. figs. 1, 2; and pl. xi. fig. 1, B. *s*.

To demonstrate the connexion of the cerebellum with a bundle of the restiform body, the medulla oblongata must be pushed to one side, and the auditory nerve and a thin layer interposed between the medulla and the cerebellum, scraped off with the handle of the scalpel. The second bundle of the restiform body, reckoning from the posterior pyramid, will then be seen to plunge into the cerebellum. By entering the point of the knife at the insertion of this bundle, and cutting the cerebellum vertically, so that about two thirds of its substance may be left externally, and the other third remain internally, the communication of the cerebellum with the medulla oblongata; its ganglion, from the entrance of the connecting bundle of the restiform body to about its middle; the ramifications of the white substance; and the peripheral extremities of the various branches universally covered with cineritious matter, constituting the appearance denominated arbor vitæ, will all be exposed. These peculiarities are represented in pl. viii. fig. 1.

To see that the uniting fibres of the cerebellum,

composing the annular protuberance or commissure, are distinct from those of the bundle that connects it with the medulla oblongata, the last-named part must be turned aside, and the vocal, glosso-pharyngeal, facial, and auditory nerves removed with the handle of the scalpel; the fibres of union will now be seen gathering themselves from the peripheral parts, and lying over the bundle that springs from the medulla oblongata, and plunges into the cerebellar ganglion. Finally, every cut in the direction of the cerebellar lamellæ exhibits a white surface, as is pictured in pl. viii. fig. 2.

SECTION VI.

Of the Brain.

In the preceding section, I have shewn anatomy, physiology, and pathology, concurring to prove the cerebellum a single and peculiar instrument. In this respect, it is the opposite of the mass properly styled brain. I have, already, exposed the anatomical proofs of the brain's complexness, and for the evidence which physiology and pathology afford, referred my reader to the respective treatises upon these subjects *.

Conviction of the brain, properly so called, being an assemblage of instruments, is readily obtained; but to specify the limits of these instruments, individually, in the different species of animals, is a matter of extreme difficulty, if it be not, perhaps, impossible.

Let us follow the procedure of nature in this part of our inquiry, and, commencing with the most simple brains, pursue them in their increasing complexness as we mount in the scale of beings, until we arrive at that of man, the most complicated of all. They who have gone into the comparative anatomy of the nervous masses,

* Phrenology or the Doctrine of the Mind; Lond. 1825, and Observations on Insanity; Lond. 1816.

have constantly assumed the human brain as their type of comparison. This they have always viewed as a simple mass; and then, the hemispheres, the three lobes, the callous body, the anterior, middle and posterior commissures, the infundibulum, the mammillary bodies, the fornix, the septum lucidum, the hyppocampus's foot, the streaked bodies, the optic thalami, the semicircular tænia, the quadrigeminal tubercles, the aqueduct of Sylvius, the valve of Vieussens, the peduncles of the brain, the annular protuberance, the medulla oblongata with its pyramidal, olivary, and restiform eminences, and lastly, the ventricles and their communications, have been their grand objects of comparison. The existence of parts, as this specimen of the nomenclature, in use, sufficiently proves, appears, therefore, to be admitted, or denied according to mere physical indications, the form and situation of the masses being especial guides to the conclusions formed.

But this mode of studying the comparative anatomy of the brain, is insufficient. In the first place, it is certain that the mass, styled brain, consists of a multiplicity of instruments performing particular functions; again, it is undeniable that the cerebral parts, as they are spoken of, in systems of descriptive anatomy, do not constitute entire and special organs; that several of them, indeed, occasionally, go to compose a single apparatus, a circumstance which we have observed

in reference to the cerebellum, when treating of that part. Further, it is no less obvious that the identity of the individual organs in the various classes of animals, ought to be determined by means of physiology, seeing that the forms of those which are known to be analogous often vary immensely. I have already said,that no anatomist, who, in ignorance of the sense of smell, should examine the mere configuration of the encephalic masses, would venture to maintain that the olfactory nerves of the skate, flounder, fowl, seal, and ox, were masses performing analogous functions. And the outward appearances of the other cerebral instruments are not less diversified than are those of the organ of smell. It is, consequently, in vain attempting to advance the comparative anatomy of the brain, without a knowledge of the affective and intellectual faculties of animals, and of the functions performed by the different cerebral organs.

The brain being made up of very many parts, whose functions are entirely dissimilar, the connexion of these with the nervous masses of voluntary motion, and of the five external senses, with the spinal cord in particular, requires to be examined. The cerebral organs have several primary roots, or bundles in the medulla oblongata; these bundles have been particularized by the names anterior and posterior pyramidal, and olivary, and restiform bodies. From what has

been already said, however, it is evident that the last-mentioned masses do not belong exclusively to the brain; we have seen that they include the roots of several nerves, and the primary bundles of the cerebellum. In the human kind all the three portions of the medulla oblongata are very distinct; but they severally become less and less evident as we descend in the scale of beings, and when we arrive at fishes we are almost tempted to doubt their existence altogether. Some, indeed, go so far as to deny these animals a brain. To me, however, it appears that every vertebral animal has a brain in the strict and proper sense of the word; all have a nervous mass superadded to the nerves of the external senses and voluntary motion; and fishes, which besides a cerebellum, seem to have ganglions of nerves of sense only, may be proved to possess a true brain in addition. The proof lies in this, that ganglions in general are proportionate to the nerves arising from them; but the ganglions of the skate, and the three pairs of ganglions which, in the eel, are regarded as the origins of the olfactory nerves, and the optic ganglions of the carp, pike, and many others of the class, are much too large in proportion to the nerves which issue from them. I, therefore, contend, that the olfactory and optic nerves of fishes communicate with certain cerebral parts, destined to peculiar functions, pre-

cisely as the same nerves do in birds and the mammalia, with this difference only, that the masses they communicate with are of different sizes in these different species of animals. I repeat then, that with M. Arsacky *, I conceive the complex structure of the optic ganglions in fishes to explain the functions which in reptiles, birds, and mammiferous animals, are obviously performed by certain parts with which the optic nerves communicate. I apply the same idea to the ganglions of the olfactory nerves. In the eel, for example, I only give the anterior pair to these nerves; and in the skate, no more than the outer parts of the ganglions with which they communicate.

M. Carus, in his work on the brain †, broaches an idea that deserves a passing notice; it is to determine whether, when the cerebral parts are separated from each other at their peripheral extremities, this is to be regarded as a sign of perfection or of imperfection. M. Carus himself considers the brain to be perfect in proportion as its masses approach unity. The brain of the eel is, according to him, extremely imperfect, on account of the separation of its constituent parts.

This opinion seems to me too general, and but little satisfactory. We know that the brain

* Dissertatio de Piscium Cerebro et Medulla Spinali, Halæ, 1813.

† Carus, Darstellung des Gehirns, Leipzig, 1814.

and the cerebellum are always separate from each other. In proportion too as the last is perfected in the four classes of vertebral animals, its different parts become more numerous, more distinct, and lie farther from each other, especially towards their peripheral extremities. The brains of reptiles, of birds, and of several mammiferous animals, consist of two smooth hemispheres; in proportion, however, as the brain in superior classes of beings has more numerous offices to perform, that is, as it increases in perfection, the division into lobes becomes distinct, and convolutions appear. The cerebral hemispheres of the human fœtus are at first smooth, but as the encephalon is developed, the separation of its peripheral parts grows ever more conspicuous.

I divide the functions of the brain into two classes: *viz.*, affective and intellectual; and, in harmony with this physiological division, I recognise two kinds of cerebral parts. The anterior pyramidal bodies I consider the rudiments of such as belong to the intellectual operations; and the other bundles of the medulla oblongata (in man they consist of the olivary and part of the restiform bodies) which run across the annular protuberance to communicate with many of the cerebral masses, as the roots of those that pertain to the affective manifestations.

This separation into two systems of parts is

very evident from the medulla oblongata upwards, as far as the pretended optic thalami and striated bodies in man and the mammalia. Let us then examine them one after another through their entire course, commencing with the bundles of the intellectual faculties.

The pyramidal bodies are scarcely to be demonstrated in birds, and still less are they to be seen in reptiles and fishes; in the lowest mammiferous tribes, however, they are abundantly evident. They differ in general size and length, not only in the various species of animals, but also in individuals of the same, especially of the human kind. In man they usually commence about twelve or fifteen lines below the annular protuberance. As they approach this mass, they increase gradually in size, and it is in consequence of this structure that they have obtained their name.

There is a striking peculiarity in the mode of origin of these bundles: the primary fibres of each do not issue from the same side as that on which they lie, but uniting, in the first instance, into two, three, or as many as five little cords, they cross the mesial line of the body, one above another, from below upwards; the bundles of the right pyramidal body, therefore, come from the left side, and those of the left pyramidal body from the right side of the

spinal cord. The structure just described is termed the decussation of the pyramidal bodies. It is a constant peculiarity, but it is modified as the number of decussating cords is concerned. When they are numerous, the appearance that results very much resembles plaited straw. In some very rare instances the two pyramidal bodies cross, as entire and undivided masses, from one side to the other.

The decussation of the pyramidal bodies is a point of much importance in a physiological and pathological point of view. It is very long since cases of disease impressed the idea of a nervous decussation on the minds of medical men. Lesions on one side of the head were often observed to occasion so unfortunate a symptom as palsy on the opposite side of the body. Hippocrates himself mentions the circumstance, but Aretæus was the first who attempted to explain it, by supposing a decussation of the nerves at their origin in the brain. Dion Cassius is the next who speaks of a decussation of the cerebral nerves and spinal cord, but with him the subject dropt, and the attention of the medical world was only recalled to the fact in 1581, by Fabricius Hildanus. The true decussation of the pyramidal bodies, however, was first described by Mistichelli, in 1709; it was noticed by Petit in the year following, and at later periods by Lieutaud, Santorini, and Win-

slow. The same authors also speak of other decussations, but probably on mere supposition.

Modern anatomists, before Dr. Gall and myself, were divided in opinion upon the subject of decussation. Many admitted the fact, but no one pointed out the place of its existence. Vicq d'Azyr, for example, confounds the simple transverse fibres between the two halves of the spinal cord with the true decussation of the pyramidal bodies. Many others, among the number Prochaska, Barthez, Sabatier, Boyer, Dumas, Bichat, and Chaussier, have, in the most positive terms, denied the decussation of the pyramidal bundles altogether, as we have shewn in our reply to the report of the Committee of the French Institute upon our Anatomical Memoir.

To demonstrate the decussation of the pyramidal bundles, we do not require any such maceration as Santorini believed necessary. It is sufficient to strip off the pia mater to shew the structure. Let a slight cut be made through the membrane in the median line, without implicating the cords beneath, the edges then separated gently, and the decussation will appear. It will now be easy to reckon the number of bundles, and to take them away in succession with the handle of the scalpel. (Pl. viii. fig. 1—1.)

The decussation at this place is incontestable; but whether there be any similar peculiarity in other situations, and whether that of the pyra-

midal bodies suffices to explain all pathological phenomena, are points that still remain undetermined.

Some authors believe that the bad symptoms which attend lesions of the encephalon are always manifested on the side of the body opposite to that on which the injury occurs. Others again cite cases where injuries of one cerebral hemisphere have caused pathological symptoms on the same side of the body. "Although the palsy of the body," says Haller*, "produced by injury done to the brain, be commonly manifested on the opposite side, it often enough happens, that derangements of the brain and cerebellum affect the same side (as that on which they happen)." He quotes De Haen, Schlichting, Morgagni, and others, in illustration of the fact. Prochaska believed that when the opposite side of the body suffers from cerebral affections, it is principally when the striated bodies are the seats of disease.

Anatomy has as yet demonstrated no other decussation in the medulla oblongata than that of the pyramidal bundles. No crossing of fibres has ever been found of the primary bundles of the cerebellum, nor of the posterior cerebral lobes, although physiological experiments and pathological facts tend alike to prove that the influence of the cerebellar hemispheres is propa-

* Physiologia, t. iv. p. 333.

gated to the opposite side of the body. May not the cerebellum possibly act only through the medium of the brain? To such an hypothesis the inability to perceive any proper lesion of the brain cannot be well opposed as an objection; because it is not at all times possible to determine precisely whether the cerebral fibres are healthy or diseased. The lesions may be perceptible in one and not in another part. I conceive that the cerebellum may be evidently disordered, and that the brain may suffer, in consequence, without our being able to detect any traces of disease in its organization, whilst the opposite side of the body exhibits pathological symptoms. The connexions of the various parts, and the resulting influence of each on the others reciprocally, render observations on these matters difficult, and the conclusions deduced more or less suspicious. Farther researches on the decussation of the nervous parts, not immediately connected with the masses of the anterior pyramidal bundles, are still wanted. The optic nerves decussate partially, and this is the cause why the eye is frequently deranged on the same side as that on which the brain is diseased.

Let us now follow the pyramidal bundles in their course towards the annular protuberance; and first, let us remark the fibres which are detached from the pyramidal, towards, and around the olivary bodies, the media of communication,

probably, between these different bundles of the medulla oblongata. (Pl. viii. fig. 2, 64.) May not these connecting fibres explain the influence of the lateral cerebral parts upon the opposite sides of the body?

The pyramidal bodies, just as they enter the annular protuberance, are somewhat contracted in their thickness (ib. *c*), but they are, by no means, interrupted in their course. Immediately after having plunged into that mass, they separate into several bundles, and are mingled with cineritious substance (ib. *f*). Here, many new fibres arise and join the others; all advance, some of them disposed in layers, and some intersecting the bundles of the annular protuberance. The pyramidal bodies are so much increased in their passage, that on emerging from the annular protuberance, they compose the anterior and outer two-third parts of the cerebral crura or legs (ib. *g*).

To see the structure of the annular protuberance distinctly, that is to say, to see the transverse uniting fibres of the cerebellar hemispheres, the longitudinal fibres communicating with the pyramidal bodies, and crura of the brain, and the cineritious substance intermingled with each, an incision of about a line in depth must be made across the transverse fibres; if the cut be made deeper than this, it must not be carried in a straight line, but in the slightly-curved direction of the longitudinal bundles; the transverse must now

be separated from the longitudinal layers with the scalpel, by pushing those, on the outside, towards the hemispheres of the cerebellum, and those on the inside, towards the mesial line of the annular protuberance.

By this means, the mode in which the longitudinal, or bundles of the pyramidal bodies are augmented in the annular protuberance, as it were in a true ganglion, is made evident. (Pl. vii. fig. 2, 88, and pl. ix. fig. 2, *f*.)

If these longitudinal bundles only are to be examined, it is sufficient, by pushing the handle of the scalpel upwards from its inferior edge, to remove the transverse layer of the annular protuberance that covers them.

Certain it is, therefore, that great errors are committed when the two crura of the brain are described as blended together, and the annular protuberance is styled a compound of the medullary or white substances of the brain and cerebellum.

The great bundles called crura of the brain, thus appear to be, in part at least, a continuation of the pyramidal bodies increased in size and in perfection. These crura, as they advance, also contain cineritious matter in their interior, from which, additional fibres are continually sent off to join and strengthen those that have come from below.

In mammiferous tribes, the cerebral crura are

very evidently divided into two parts, *viz.*, an anterior and external, and a posterior and internal mass. Two superficial furrows mark their limits respectively. They bear no regular proportion to each other. In the human kind, the anterior and external portion composes, as I have already said, two-thirds, at least, of the entire crura; but in the lower animals, the posterior is, by much, the more considerable portion of the two.

Before advancing further in our examination of the longitudinal bundles which we have followed from the pyramidal bodies across the annular protuberance, let us first consider the origin and progress of the bundles that compose the posterior and inner portion of the cerebral crura.

I have already had occasion to say that anatomists, besides the pyramidal, speak of the olivary and restiform bodies of the medulla oblongata of man. I have also shewn that the restiform bodies contain the origins of the primary bundles of the cerebellum, and of the vocal, glosso-pharyngeal, facial, and trigeminal nerves. The remaining fibres of these, and the fasciculi of the olivary bodies, mount behind the ganglion of the pyramidal bundles in the annular protuberance, and joining themselves with, aid the completion of the cerebral crura. In this course, they gain some increase in size, which, however, is inconsiderable compared with that of the pyramidal

bundles. (Pl. vii. fig. 2, 87, 90, and pl. ix. fig. 2, *a* 70, 70.)

The olivary bodies are, themselves, true ganglions, and present the general forms (pl. ix. fig. 2, *a*,) and modifications observable in the ganglion or dentated body of the cerebellum. (Pl. ix, fig. 2, *s*.) Their size varies greatly in different individuals. The cineritious and white substances are observed to be variously distributed throughout them. The modified appearances of the interior of the olivary bodies depend, as in other cases, on the mode in which they are incised for examination.

The second, or posterior and inner portion of the cerebral crura, is intimately connected with the quadrigeminal bodies. In the mammalia, it is much more voluminous than the anterior mass; and as we descend in the scale of beings, its relative proportion increases continually.

These two portions of the cerebral crura contain, so to say, the roots or primary bundles of the hemispheres of the brain, properly so called. They, however, it is evident, must be immensely increased in volume before they can form such a mass as the brain. It is at the upper extremity of the anterior portion, where the optic nerve winds over, and is attached to it by a pulpy layer, that is to say, at the outer part of the striated bodies, that the great augmentation takes place.

After this, the fibres advance of unequal lengths, and expanding into layers covered on their peripheral extremities with cineritious substance, ultimately form the inferior, anterior, and external convolutions of the front and middle cerebral lobes.

To shew that the lower and inner convolutions of the middle lobe, are formed by the anterior and outer crural bundles, the middle lobe must be removed. This is easily effected, as it is separated from the anterior lobe by the fissure of Sylvius. Besides the depth and extent of the Sylvian fissure by this means exposed, certain short convolutions which do not reach the surface, will also be brought into view. These convolutions lie hidden between the middle lobe and the superior cerebral parts. The bundles which issue from under the optic nerve, will also now be seen to belong to the middle lobe, and to the anterior part of the posterior lobe. (Pl. viii. fig. 1, *w*, *w*.)

If the entire outer part of the striated bodies be removed, the manner in which the convolutions, situated along the middle region of the hemispheres, on a level with the temples, arise from the bundles in continuation with the pyramidal bodies, will be made apparent. (Pl. ix. fig. 1.) The pyramidal bodies, their ganglions in the annular protuberance, the anterior and outer portions of the cerebral crura, and the convolutions

in which their bundles terminate, are always developed in the direct ratio of each other.

Let us now trace the posterior and inner bundles of the cerebral crura to their termination. These plunge into a thick, massy, and firm ganglion, flattened in the middle, and unequal above, and posteriorly; this is generally known under the name of optic thalamus, it having been long regarded as the origin of the visual nerve. The error, here committed, I have exposed in speaking of the apparatus of vision.

These ganglions, commonly called thalami, are developed in the direct ratio of the cerebral convolutions dependent on them. The posterior and inner portions of the cerebral crura being larger in the lower animals than the anterior and outer masses of the same, it follows that the convolutions of the upper and posterior parts of the hemispheres, must be more considerable than those of the anterior and middle lobes. The most internal part of the thalamus, is the largest in animals, consequently, so is the mass of convolutions that belongs to it.

In the interior of the cerebral ganglion we are now discussing (pl. ix. fig. 2, *p*), there are a great number of very fine nervous filaments; these unite at its superior edge into bundles, which then diverge towards the convolutions in the manner of rays.

The two portions of the ascending masses, called

cerebral crura, which I have just described, may be separated from each other either by the blow-pipe, or a stream of water. At the place, however, where they issue from the thalami to enter the striated bodies, their fibres are all so intimately united by a transverse tissue, that any farther partition of the two portions becomes impossible.

The anterior bundles of the thalamus traverse the striated bodies. These are so named, because, when cut in the usual mode, anatomists fancied they beheld alternate streaks of white, and of cineritious substance. But the gray matter is not disposed in bundles; it is a mere mass traversed by white diverging fibres. By scraping away to about the middle, or to the place where the large white bundles pass, the cineritious substance will be seen disposed in the form of streaks between them; a closer inspection, however, proves that it only lies in the intervals between the fibrous bundles.

The masses styled optic thalami and striated bodies, therefore, are true ganglions, in which the primary bundles of the brain are increased in their progress to completion in the convolutions of the brain; for the radiated diverging fasciculi expand into layers, and, being covered with cineritious substance on their extremities, compose the convolutions.

The faultiness of the ordinary method of ex-

amining the structure of the brain will now be, in some degree, appreciated. Instead of tracing the masses from their rudimentary state upwards to completion, anatomists have been in the habit of commencing the dissection by mutilating the parts when already arrived at perfection.

By scraping the parts, Vieussens followed, and has given a rude drawing of the nervous bundles in connexion with the pyramidal bodies. These fasciculi, however, he derives from his *oval centre;* he was altogether ignorant of their destination—the formation of the convolutions. He conceived them all to unite in the pyramidal bodies; he, therefore, had no idea of the successive additions to, or of the augmentations of, the primary bundles.

Vicq d'Azyr has attempted to imitate the preparation of Vieussens in his twenty-second and twenty-third plates; but the mass of gray substance, and the nervous bundles which traverse, and partly arise from it lying obliquely, he could not possibly succeed by his horizontal incisions. In the striated bodies he only saw alternate streaks of white and gray substance; these he also regarded as coming from above downwards, to pass united in a single bundle across the annular protuberance. He has, moreover, neglected several rudimentary bundles entirely; he regarded the streaks of the superior as shorter than those of the inferior parts, in consequence of having cut them first,

and he was quite ignorant of their prolongation into the convolutions. He only makes them proceed forwards, overlooking their sideward and backward directions altogether. Vicq d'Azyr, therefore, has done nothing more than picture, and that in a faulty manner too, mutilated pieces of the encephalon.

I conceive it of importance further to remark, that the nervous fasciculi are less numerous but larger in the posterior and middle than in the anterior region. In the latter they are very numerous, but also very small. (Vol. ix. fig. 2, and pl. x. fig. 1, A. P. P.) This anatomical fact corresponds with what we know of the physiology of the brain, and explains wherefore the organs situated in the forehead are more numerous but smaller than those which lie in the occipital region.

Let us now glance over the comparative anatomy of the cerebral parts, the structure of which we have examined particularly in man.

The anterior pyramidal bodies are generally distinct in mammiferous tribes, but they are comparatively smaller than in the human kind. The lateral parts of the medulla oblongata are not formed like the olivary and restiform bodies with which they correspond in man; their fibres, however, are certainly prolonged beneath and across the transverse uniting fibres of the cerebellum. At their exit from this mass, the ante-

rior and external parts of the cerebral crura are observed to be proportionately smaller than the internal and posterior portions. The relative size of the two portions of the crura, indeed, are found to vary exceedingly in the different tribes of the mammalia. The anterior and outer bundles, or continuations of the pyramidal bodies, extend under the optic nerves (which by their external edges communicate with the cerebral masses precisely as in man), and on the external parts of the striated bodies gain an increase of size in the direct ratio of the anterior convolutions of the middle lobes, of the outer convolutions of the front lobes, and of those around the fissure of Sylvius. The description of this external portion of the striated bodies is entirely omitted in the work of Tiedemann. The posterior and internal parts of the cerebral crura are intimately connected with the quadrigeminal bodies; they then plunge into the pretended optic thalami, and join themselves to the striated bodies; their structure, in short, is analogous to that of the same parts in man.

In birds and the inferior classes all traces of pyramidal bodies, visible in the mammiferous tribes, disappear, and all analogy, as regards form, with the medulla oblongata of man is lost. The medulla oblongata, however, of all vertebral animals is invariably augmented downwardly and outwardly in proportion as nerves of greater or

smaller size are detached, or as the rudimentary bundles of the proper cerebral masses are thence derived. The mere outward form, here as elsewhere, is not the essential consideration. It is quite certain that several parts of the medulla oblongata proceed forwards, and pass under the optic nerve; and that in birds and reptiles there lies a mass below the posterior cerebral lobes, and on the inner side of the crura, which resembles in every thing the supposed optic thalamus; and, finally, that in the two classes mentioned, the advancing bundles encounter true striated bodies. (Pl. xi. fig. 2 and 3, *l. l.*)

The pretended optic thalami and striated bodies, or the two principal ganglions of the cerebral hemispheres, consequently, exist in birds and reptiles, precisely as they do in man and the mammalia. M. Serres must therefore be mistaken when he denies striated bodies in the brains of these animals *.

Dr. Gall and I were unquestionably the first who distinguished the true optic ganglions from the supposed optic thalami, which are masses belonging to the brain, and who demonstrated the relations between the two cerebral ganglions and the hemispheres.

Among fishes, in fine, certain cerebral masses in the form of ganglions, and covered externally

* Rapport, &c. p. 70.

with cineritious substance, are always to be found. When treating of the optic and olfactory nerves, I proved that the entire encephalic mass could not be destined to originate them. But it is a difficult task to compare analogous cerebral parts in different tribes and classes of animals. In fishes the medulla oblongata is evidently continued forwards, and from it are detached, in succession, the primary bundles of the cerebellum, and of the cerebral nerves; but M. Serres promulgates an error when he says, that the cerebral hemispheres of fishes are simple rounded bulbs, lying before the quadrigeminal tubercles, in which the crura expand. Two longitudinal bands we can observe continued onwards to the olfactory nerves, with which a larger or smaller number of ganglions communicate; but whilst the functions of these shall remain undiscovered, they can only be designated according to their numerical order. (Pl. ii. fig. 1 and 13; 1, 2, 3, 4.) The anatomists also certainly err, who speak of the restiform bodies as simple bundles. The olivary bodies, as they are not to be demonstrated in the greater number of animals, cannot belong to the quadrigeminal tubercles, as M. Tiedemann supposes.

In reptiles, birds and the mammalia, the prolongation of the two great cerebral ganglions compose the hemispheres, as they are styled, of the brain. The volume of these varies extremely

in different kinds, and even in different individuals of the same species of animals, and this not only in their totality, but also as their various portions are concerned.

The external surface of the cerebral hemispheres in reptiles, birds and several mammalia, is smooth. The division into three lobes, however, is always marked by slight furrows, and the individual parts are dissimilarly developed in different situations. In the greater number of the mammalia, as in man, the hemispheres are convoluted, and furrowed to a greater or less depth.

Of the Structure of the Convolutions, and of the possibility of unfolding them.

The unfolding of the cerebral convolutions has sometimes been considered as the essential point in the anatomical discoveries of Dr. Gall and myself. This is the reason why some have taken particular pains in combating the possibility of this operation. The fact is in itself of great importance; it affords several explanations that particularly interest both physiology and pathology. Many cases of disease would be quite inexplicable without a knowledge of the structure of the cerebral convolutions; yet not this, but the demonstration of the plurality of the nervous instruments, their independent existence, and

their connexions with each other, constitute the essentials in our anatomical inquiries.

It has often been, and is still said, that the vascular membrane, by plunging at intervals among the white substance, to convey the blood-vessels necessary for its nourishment, is the cause of the cerebral convolutions and anfractuosities; but no part of the structure is thus mechanical. The convolutions internally consist of white fibres, which are covered on their extremities with cineritious substance. These fibres, which terminate the nervous bundles of the cerebral crura, are not all of the same length. Many, especially of those which are situated on the outer sides of the convolutions, terminate immediately beyond the exterior walls of the cavities; the others extend to distances progressively greater as they run more centrally, those of the interior extending the farthest of all. It is in consequence of this peculiar structure that prolongations and depressions are formed on the surface of the hemispheres. The cineritious substance follows all the forms composed by the white fibres, and covers every elevation and depression with a layer.

The fibres of analogous bundles are not prolonged in every individual to the same distance, not even in the two hemispheres of the same brain. I find that the parts which are most largely developed have the fewest inequalities

on the surface of the convolutions, the fewest depressions, and even the smallest number of anfractuosities. They are simply voluminous, and their peripheries are regular and smooth.

The convolutions are for the most part inclined slightly to the roof of the ventricles; they rarely stand up vertically. Their peripheral edge is very frequently depressed, and this gives them an appearance similar to that which a fold of paper takes when its edge is pressed slightly inwards. (Pl. ix. fig. 1 and 2.)

When a convolution is cut across vertically, the white substance will be observed of greater thickness at its bottom than at its top. This happens from the nervous fibres losing themselves successively on either side in the cineritious enveloping layer, whilst those of the centre only run to the extremity.

A clean cut only shews the white substance of the convolutions as a simple mass. No line of separation can be perceived in any direction. Nevertheless, it may be demonstrated to consist of two layers covered externally by cineritious matter. These layers meet in the middle line of the convolutions, and are slightly agglutinated by means of a very delicate nevrilema.

On this structure is founded the possibility of separating, without injuring, the fibrous layers, and thus of extending or unfolding each convolution into a simple sheet.

Before citing any anatomical evidence in support of the above fact, I shall give, as briefly as possible, the history of its discovery. Dr. Gall having had several opportunities of dissecting hydrocephalic heads, found, as Morgagni had before him, the brain distended like a large bladder, several convolutions having entirely, and others in part, disappeared. The internal surface of the enlarged cavities was uniformly white; and, generally, the nervous fibres and the blood-vessels that accompanied them were distinctly perceptible. He also met with a female, fifty-four years of age, whose head was much enlarged, without doubt in consequence of considerable dropsy of the brain. In person she was thin, but she was as active and intelligent as women usually are in her own sphere of life. Dr. Gall being convinced that the brain is indispensable to the intellectual manifestations, drew, as I have said in the preface, the same inference as Tulpius had done before, *viz.*, that the encephalic mass cannot be disorganized or destroyed in those persons who, being affected with hydrocephalus, still preserve their understanding entire; and farther, that the structure of the brain must be different from what is commonly supposed.

The female, whose case is quoted above, happening to die of an inflammation of the bowels, Dr. Gall found that the cerebral cavities con-

tained about four pounds of pure and limpid water. The convolutions of the upper part of the forehead, and of the superior region of the head, had disappeared entirely; lower down, however, they were distinct in different degrees. In the interior of the great cavities, the fibrous structure and the blood-vessels appeared very conspicuous. I saw this head dissected at Dr. Gall's house, but neither of us at that time had any definite idea of the mode in which the cavities had been enlarged, the convolutions obliterated, and the cineritious substance made to appear spread over the entire surface, like an envelope of nearly equal thickness.

This case, however, gave a new impulse to our anatomical inquiries on the encephalon. We began by attempting to imitate artificially the state of the brain in hydrocephalus. Having stripped off the pia mater, we insinuated our fingers into the great cavities; and by pressing, more particularly against their posterior walls, we found, with pleasure, that after overcoming a slight resistance at the commencement, the convolutions separated along their interior, with all readiness, into two parts. Even this rude experiment made us conceive the possibility of the gradually increased and unremitting pressure of the water, as it accumulated in hydrocephalus, unfolding the hemispheres into a membraneous

sheet, without destroying any of the nervous fibres.

By degrees our anatomical discoveries were increased, and our ideas of the change effected on the cerebral masses in hydrocephalus became exact.

The imagination of Dr. Gall's auditors was somehow more struck by the experiment above related, than by the whole of our cerebral anatomy besides. Our opponents, by the same reason, have conceived themselves particularly called upon to disprove its practicability. In their zeal, they have sometimes put sentences into our mouths which we never uttered; we have been made to say, for instance, that the entire brain could be unfolded into a membrane without any laceration of fibres; our idea has also been travestied, by reporting that we regard each separate convolution as a sort of little purse.

The question concerns the structure of the convolutions only, and the possibility of proving them composed of two distinct layers, separable from each other. Let us, therefore, proceed to the inquiry.

If a convolution be cut vertically across to its base, a very gentle pressure with the finger on the cut surface will suffice to separate its two fibrous layers. The surfaces by which these were agglutinated will, even after this rude procedure,

remain perfectly smooth and equal. At the base of the convolutions there is a mass which prevents any further disjunction of their component layers. Of the structure of this mass I shall speak, when I treat of the *commissures*, or uniting fibres of the cerebral parts.

If a portion of hemisphere, lying above the ventricles, be taken in one hand, and the ventricular surface be lightly pressed on by the other, the mass at the base of the convolutions, which has just been mentioned, will be torn, and the two layers of the several convolutions then yield readily and may be forced apart by the fingers. Whilst this is doing, we may always observe a slight furrow along the line of every separation, and the blood-vessels coursing along the same. Now this could not happen, were not the convolutions composed of two fibrous layers, not united by transverse fibres, but simply agglutinated by means of a fine and yielding cellular tissue.

If the convolutions be cut off externally to the cavities, they may be readily unfolded, and without any tearing of parts.

The convolutions, hardened in alcohol, in diluted nitric or muriatic acid, or in oil by simple boiling, may also be unfolded with perfect ease in the middle line, and only in the middle line of their agglutination. No vestige of laceration will there be perceived, but the fibrous expan-

s on either side will become exceedingly distinct.

It is objected that the fibres may be separated at every point, and by the side of the middle line of the convolutions. Now this is as it ought to be, because each layer is made up of many fibres, running in one and the same direction. The fibres of every ligament and muscle may be parted in like manner; but this fact does not do away with the existence of entire ligaments and muscles, distinct and easily separable from each other. Moreover, the nervous fibres on the outer surfaces of the layers, as they are continually and successively dipping into the cineritious substance, may the more readily be separated from each other, the more the bundles lie externally on which the attempt is made.

To prove further that the convolutions consist of two fibrous layers but slightly agglutinated, the following experiment may be tried:—

Let a convolution be cut transversely, and blown upon at random through a pipe; both the white and the gray substance may, although with some difficulty, be destroyed; but no disjunction of fibres nor of the two substances will be effected. But let the stream of air be directed on its middle line, and it will instantly be split from the apex to the base. (Pl. ix. fig. 1, 1—2.) If the same experiment be made on a convolution that

is slightly depressed at its summit, it will open at the base by a simple cleft, but at the upper part this will branch off towards the two corners. (Pl. ix. fig. 1. 1—2.)

When, instead of air, water is thrown with a syringe on a convolution cut transversely, the separation is operated in a similar manner: this fluid too, may be pushed for three or four inches along the middle line, between the layers; it will even follow all the windings, and fill all the subdivisions of the convolutions that occur in this space. If after their injection the superior edge of the convolutions be cut away longitudinally, to the depth of about two lines, they will be found divided into two equal parts; and the manner in which the fibres penetrate and lose themselves in the cineritious substance on either side will also be distinctly seen.

Water thrown with violence upon the outer surface of a convolution will wash away the gray and one half of the white substance; as soon, however, as it reaches the middle line, it will penetrate to the right and left, and separate the two layers to the extent of an inch or two each way, as in the former experiment. Here also, as in the former case, the direction and distribution of the nervous fibres will be rendered very apparent.

All these demonstrations prove incontestably that the convolutions consist of two fibrous layers

agglutinated together, and surrounded by cineritious substance. Nevertheless, authors still continue to speak of the *cerebral pulp*, or of the medullary and pulpy substance of the convolutions. But the idea of a mere pulpy matter is in contradiction to all known anatomical and physiological phenomena. Were the white substance pulpy, it would be destroyed or carried away by a stream of air or water directed upon it. It would be impossible, on the supposition of a pulp, to account for the similar result of the various experiments related, *viz.*, the regular separation of the convolutions into two layers along the course of their middle line.

In connexion with the idea of a cerebral pulp, that of hydrocephalus, to any considerable extent, becomes an impossibility, because the slightest distension of any one portion of the brain would tear the pulp, and the disease could no longer proceed. But many cerebral parts are often seen completely unfolded, and still resisting the contained fluid, although they be stretched into a membrane scarcely two lines in thickness. Similar changes, too, are frequently undergone by the majority of the convolutions, without any laceration or destruction of parts.

Some anatomists appear to have felt this difficulty, and, to escape, have said that the cineritious substance was very tenacious, even more so than the white, and that this quality enabled it to re-

sist laceration, and to suffer the expansion peculiar to considerable hydrocephalus.

But all good anatomists know full well that the cineritious is much softer than the white substance, that the first is never seen disposed in layers, except where the last occurs in distinct bundles; indeed, that in the very places where the cineritious substance appears in layers, it falls into pulp the moment the white fibres are taken away.

In hydrocephalus, some anatomists have pretended to see nothing more, no other change, than a mere extension of the cerebral cavities. But on this supposition, how may the entire disappearance of the convolutions be explained? Were the cavities merely distended, the convolutions would only be separated more widely from each other; they would never be unfolded; their component layers would not, from a naturally vertical, assume a horizontal position.

The structure of the convolutions once familiar, however, we readily conceive a capacity in the hemispheres to undergo great changes without the occurrence of any actual disorganization. We even perceive that when the cerebral fibres chance to be elongated, this does not necessarily imply derangement of intimate structure: vision is well known often to remain perfect when the optic nerve is very much lengthened.

Anatomy, consequently, shews how it comes

that individuals affected with dropsy of the brain may manifest all their intellectual and affective faculties. We cannot now say with Walter, Ackermann, and so many others, that in hydrocephalus there is destruction or absorption of the organization, and that the mental functions are all necessarily annihilated. The physiology of the brain being now established, the existence of this mass of organs is seen clearly to be indispensable, and its disorganization impossible in those hydrocephalic persons, who exhibit affective and intellectual faculties. All this is made evident by our discoveries in anatomy and physiology.

It still remains for me to make some inquiries into the comparative anatomy of the cerebral hemispheres. To shew the presence of the brain in the lower animals is not enough; the particular organs that compose the hemispheres must be determined in addition; the resemblances to the three cerebral lobes of the human kind, and to the individual portions of each being also demonstrated. Anatomists are not even agreed as to the existence of the posterior lobes in all mammiferous tribes. Messrs. Cuvier, Tiedemann, Serres, and others, maintain that the posterior lobes of the brain are only found in man and the quadrumana. They rest their opinion on the fact of the cerebellum, in all the other classes, being uncovered by the brain. The conclusion here, however, is faulty, and the generally horizontal pos-

ture of animals explains, in the most satisfactory manner, why the cerebellum, instead of lying under, is situated behind the posterior lobes. Let me observe, once for all, that no part whatsoever may be denied on account of mere difference of configuration. Were it thus, the existence of the front and middle lobes, in all the lower animals, might also be disputed with perfect propriety. The bulb of the olfactory nerve is covered by certain cerebral parts, in man, monkeys, and the phocæ; but in the generality of mammiferous animals and birds, it lies, altogether, anterior to the cerebral hemispheres; nevertheless, no one concludes that they, therefore, want the front lobes. On the other hand, it is a great error to assume with M. Serres*, as an axiom, that—"The encephalon of all vertebral animals is constructed after one uniform type, and with the same elements," or with M. Cuvier†, to say that—"The brains of the mammalia have the same parts as that of man."

In principle, I maintain that the cerebral hemispheres of animals are composed of a greater or smaller number of parts, as different from each other as the optic from the auditory nerves. The existence of the posterior lobes of animals is not to be doubted, seeing that the ganglion, out of which they proceed (thalamus), is found in them,

* Anatomie du Cerveau. † Anat. Comparée, t. ii.

as well as in man. Moreover, the functions of the human posterior cerebral lobes are also manifested by animals. To the above, it is still necessary to add, that variety in the peripheral expansions of individual organs, indicates neither the absence nor presence of any one in particular: one hemisphere that is entirely smooth, and another that is furrowed in all directions, may both of them contain the same elementary parts. This consideration it was which induced me to say, that the comparative anatomy of the brain could not be advanced without the assistance of physiology. With the aid of physiology, however, discoveries of great interest might, undoubtedly, be made. The analogy that exists between the brains of the cat family (pl. iv. fig. 5), of the dog tribes (pl. iv. fig. 6), of the sheep, monkey, and other kinds, is as striking as the general similarity of disposition and character of each. The same law holds in the case of man. Individual organs, however, are more or less developed in every species of the same genus. In pl. v. fig. 1 and 2, I have given representations of the brains of two species of monkey. They are, evidently, much alike considered in general; but still, the anterior lobes in fig. 1, are smaller, comparatively, than in fig. 2. The brain of the ourang-outang is figured in the same plate, fig. 3 and 4, and the brain of an idiot girl, fig. 5 and 6. There is a striking general resemblance between the two,

yet the front lobes of the ourang-outang are more considerable than those of the idiot. In a precisely similar manner are the different constituent parts of the healthy human brain dissimilarly developed, and their specification is matter of especial interest in the study of man.

Section VII.

Of the Commissures or Fibres of Union.

All the proper cerebral organs, like the other instruments of phrenic life, occur in pairs, or are double, from the medulla oblongata up to their expansion in the convolutions. This, probably, happens because of their importance, and to the end, that the congenerate parts may supply each other's places, should either chance to be injured. But in addition to the parts already described, there are others still that contribute to the formation of the brain. These have been long known by the name of *commissures*.

Anatomists speak of the great commissure or corpus callosum, and of the anterior, middle, and posterior commissures of the brain. Until Dr. Gall and I published, it was the custom to take merely mechanical views of these, without attempting to discover their relations with the other cerebral parts, their derivations, or the causes of their dissimilarity in different animals, and this too, although Vicq d'Azyr had said* that "the commissures seemed to exist for the purpose of establishing sympathetic communications between the different parts of the brain."

The successive additions made to the diverging bundles, in their course from the medulla

* Memoirés de l'Acad. des Sciences de Paris, 1781.

oblongata to the convolutions, is a point in anatomy that is now generally admitted. I conceive that I have discovered another or second order of fibres, which, with Dr. Gall, I distinguish by the title, converging fibres, or apparatus of union. This discovery, however, is disputed. M. Tiedemann calls it a chimera *. Dr. Gall, in the sixth volume of his work, in 8vo., on the Functions of the Brain, replies at great length to M. Tiedemann, and to those who dispute the converging fibres. For my part, I here address the same reproach to M. Tiedemann, which I have laid against him in another place, and in a general manner. He has admitted laws from researches made on the brain of the embryo, which are in contradiction with the structure demonstrable in the adult.

Nothing can be easier than, by dissection, to prove the two orders of cerebral fibres: the diverging and the converging, and to shew that the mass or bundle called corpus callosum belongs to the converging order.

The corpus callosum extends anteriorly and posteriorly beyond the striated bodies. (Pl. x. fig. 1.) Its thickness, at either extremity, is greater than at its middle. (Pl. vii. fig. 2, λ, μ.) The fibres which compose the folds of the corpus callosum, proceed evidently from the convolutions which form the most anterior and posterior parts of the hemispheres, and by no means from the tha-

* Bildungs-geschichte des Gehirns, Nürnberg, 1816, p. 156.

lami and striated bodies. (Pl. x. fig. 1, 39 and 40.) Their direction, consequently, is entirely different from that of the bundles constituting either of the two great cerebral ganglions. If the fibres of the supposed thalami be followed towards the posterior lobes, by scraping the parts, the converging fibres may readily be observed passing out betwixt them. (Pl. x. fig. 1, P.) Moreover, the two folds (ib. 39 and 40) of the corpus callosum are always proportionate in size to the fissures that part the hemispheres before and behind, or otherwise, to the convolutions on either side of the fissures, but by no means to the diverging fibres. The corpus callosum is softer and much larger than the bundles of the striated bodies; the fibres of either of these masses, consequently, cannot be mere continuations of the other.

But, in fact, the entire difference of the two orders of fibres cannot possibly be called in question, saving at the middle of the corpus callosum, or place opposite the striated bodies; and even here, the analogy that exists between the middle and the extremities of the mass, may be assumed a sufficient index of an analogous formation. The scalpel, however, sets the matter completely at rest. The converging mass, I must not forget to state, does indeed communicate with the great cerebral ganglions, by means of a superficial band or layer, which has obtained the title of semicircular tape-worm. On examining

the middle part of the corpus callosum attentively, its edge, opposite the great celebral ganglions, will be seen to consist of this semicircular band alone. It is composed of its own fibres, so to say, and increases in thickness as the middle line is approached, for the fibres become gradually thicker till they meet, in the same way as the folds increase, as they advance on each side to their junction.

In attempting to imitate the naturally unfolded state of the brain in hydrocephalus, by pressing upon the roof of the cavities with the fingers, a certain quantity of resistance is always experienced at the bottoms of the convolutions. This proceeds from a tissue formed by the interlacement of the two orders of cerebral fibres. This tissue once torn, the line between the layers of the convolutions is entered immediately, and they are then unfolded with perfect ease.

Were the diverging fibres or bundles of the great cerebral ganglions prolonged directly into the corpus callosum, it would be extremely difficult to understand how they could be elongated to the degree occasionally observed in hydrocephalus. The disappearance of the convolutions too, would be altogether incomprehensible; the water would act against the corpus callosum and the walls of the cavities, but there would be no reason for the unfolding of the convolutions. With the true structure in view, however, all that

happens in hydrocephalus is easily explained; there is neither absorption nor increase of the cerebral parts; the converging and diverging fibres have but to change positions; to separate at the place of their intersection, at the bottoms of the convolutions; the convolutions to split in the line of their component layers, and the change is completed. I, for my own part, feel inclined rather to recognise increase than diminution of the cerebral mass in hydrocephalus. Why, indeed, should not that happen in regard to the brain which so plainly occurs as the investing membranes are concerned? How greatly is not the arachnoid coat, the dura mater, and even the osseous covering of the whole augmented? All concurs then to prove the presence of two orders of fibres in the brain as well as in the cerebellum.

And now a question of much interest presents itself; it is this: are the bundles styled corpus callosum and annular protuberance, true commissures or organs of union? It is quite certain that the annular protuberance belongs to the lateral parts of the cerebellum, and that it appears with, and is proportionate to, these. It is also undeniable, that the corpus callosum is in relation to the cerebral hemispheres, precisely as is the annular protuberance to the lateral parts of the cerebellum. We have seen too, that both the brain and cerebellum are composed of two

orders of fibres. On the other hand, the nervous apparatus of animal life is universally double, and united in the middle line by means of commissures. I believe, indeed, that the law of commissures is quite general; but I doubt of each congenerate pair of fibres having its own commissure, or bundle uniting in the middle line. This, in the first place, cannot possibly be the case in the spinal cord and medulla oblongata, because the apparatus of union is there much less considerable than the several halves of these masses. The same thing may be said in regard to the annular protuberance and corpus callosum. These bundles, compared with the white masses of the cerebellar and cerebral hemispheres, are much too inconsiderable. It would seem, therefore, that a small mass is sufficient to unite the two congenerate halves. Still, the mass that unites, and the mass that is united, not being of equal dimensions, does not gainsay the possibility of the commissures being proportionate to the congenerate parts that are joined.

M. Serres maintains *, that the corpus callosum is proportionate to the annular protuberance, and that the hemispheres of the brain are developed in the direct ratio of those of the cerebellum. It is easy to demonstrate this error. The masses mentioned vary extremely, and are never developed directly in the ratio of each

* Rapport, &c., p. 72.

other, neither in different kinds, nor in different individuals of the same kind of animals. To be convinced of this truth, it is enough to glance over the tables of the comparative sizes of the brain and cerebellum, which various authors (among the number M. Cuvier) have drawn up. The proportion between the brain and cerebellum even varies in the same individual at different periods of life. The cerebellum attains its complete growth later than the cerebral parts generally.

As to the proportion between the annular protuberance and cerebellar hemispheres, and that between the corpus callosum and hemispheres of the brain, recognised by M. Serres, these are facts announced by Dr. Gall and me, long before this gentleman's publication appeared.

It still remains to be seen, whether or not the annular protuberance and corpus callosum are true commissures. These parts are only found in man and the mammalia; in birds, reptiles, and fishes, they are wanting. Birds and reptiles, however, have undoubtedly cerebral hemispheres, with two great ganglions; and, as in them, the other commissures, entitled anterior, middle, and posterior, are of a size proportionate to the lateral masses, and are situated as in man and other superior tribes, they cannot be assumed to supply the place of the corpus callosum. It follows, therefore, either that the union of the

cerebral hemispheres of birds is established according to another law than that of the mammalia, or that the annular protuberance and corpus callosum are not true commissures, in which event they would have to be considered as mere constituent parts of the cerebellar and cerebral apparatus. Dr. Gall and I committed an error in the first volume of our large work, when we treated of a part in birds, as analogous to the corpus callosum of quadrupeds. In the succeeding section of this book I shall show that the mass in question corresponds, not to the corpus callosum, but to the fornix of mammiferous animals. There, too, I shall prove that we did wrong, in classing the entire fornix among the commissures.

My doubts of the propriety of regarding the annular protuberance and corpus callosum as commissures, increase in consequence of the existence of two longitudinal bands, running along the middle line of the latter, forming what is called its raphé (pl. x. fig. 1), and of the layer of fibres between the raphé, and between the two halves of the annular protuberance, similar to that which occurs between the peduncles of the brain. (Pl. vii. fig. 2, λ, μ, λ.)

Lastly, Reil relates a remarkable case * of a woman, above thirty years of age, whose intellectual faculties were very limited, and whose

* Archiv fur die Physiologie, B. ii. S. 341.

corpus callosum was found split in the middle line through its entire length.

Last year, (1825,) through the kindness of Messrs. Morgan and Keys, surgeons to Guy's Hospital, London, I had an opportunity of seeing a similar case. The name of the man in whom it occurred was James Cardinal, a portrait of whom I gave, in 1815, in my work, entitled 'The Physiognomical System,' which Dr. Gall copied in his continuation of our large work, and which I myself re-published last year in my book on Phrenology. I do not think that any case more remarkable than James Cardinal's has ever been the subject of observation. He had hydrocephalus to an enormous amount, and manifested the affective and intellectual faculties. The greater part of the water was accumulated between the brain and dura mater, but the lateral cavities were at the same time distended by about a pint of fluid, which communicated freely with the liquid collected without the brain, as the corpus callosum, with its extreme folds, was split through its entire length along the median line. Its masses on either side, together with the lateral convolutions, were quite distinct. The union of the corpus callosum from this would not appear essentially necessary to the unity of function of the two cerebral hemispheres. Nevertheless, I regard the corpus callosum, as well as the convolutions, necessary to produce an organi-

zation fitted for its peculiar functions. This structure, perhaps, has some advantages as the vegetative functions of the parts are concerned; it may possibly have the same end as the cavities and anfractuosities, of which I shall speak more particularly by-and-by.

With the exception of regarding the corpus callosum as an apparatus of union, I see no reason to alter any of the other ideas relative to this mass, published by Dr. Gall and me in our Memoir to the French Institute in 1808, and in the first volume of our large work; I still maintain the proportions between its different parts and diverse cerebral masses; the dissimilar course of the diverging and converging fibres; the accumulation of fibres at its two extremities, in consequence of the anterior and posterior fissures of the hemispheres. The direction of the fibres forming the raphé, will, perhaps, be better explained in the succeeding section, which treats of the communication of the nervous apparatuses. The structure of the raphé appears to be more analogous to that of the fimbriated body, or its slip communicating with the fornix, and of the semicircular tape-worm of Haller (*tænia semicircularis*).

The idea formed of the folds of the corpus callosum, depends on the view that is taken of the mass lengthwise and from above. Anatomists, contemplating it in this way, have ima-

gined that it was folded down upon itself before and behind, in consequence of the prolongation of the cavities into the anterior and posterior lobes between the superior and inferior masses of convolutions.

The error of classing the fimbriated body and the entire fornix among the apparatuses of union is evident. To be convinced of the mistake, it is enough to remember the direction of the fibres composing these parts. The bundles of neither ever cross the median line; they always run into lateral masses, and are undoubtedly instruments of communication.

In the mammalia, there lies a band upon the medulla oblongata behind the annular protuberance, which Dr. Gall and I have regarded as a commissure of the auditory nerves. Our view in this particular may be disputed, and I leave the point still undetermined. The band, however, is certainly in connexion with the auditory nerves.

Let us now treat of the undoubted fibres of union, or of the true commissures. And, first, the nervous masses of the vertebral column are connected in the median line by a peculiar order of fibres. (Pl. i. fig. 6, 9.)

In the fourth ventricle of fishes, especially of those in which the lateral edges of this cavity resemble ganglions, certain transverse fibres may be distinctly seen behind and before the median

ganglion, and uniting the two cerebral halves. (Pl. ii. fig. 13, *e*, *e*.)

I am much inclined to think that the nervous instruments are principally connected at their origins. The two halves of the cerebellum of all vertebral animals, for instance, are united by transverse fibres running between the two primary bundles that come from the sides of the medulla oblongata. In the sturgeon, frog (pl. iii. fig. 2), and other fishes, and reptiles, where the cerebellum is so small, there is a thin white slip which joins the two sides together. In other fishes (pl. ii. fig. 13), and reptiles, whose cerebellum is larger, as also in birds, we may perceive a white layer at the bottom of the cerebellar ventricle, terminated in birds at its anterior edge by a small tubercle. (Pl. iii. fig. 8, 43.) A similar apparatus is found in man, and in all mammiferous animals.

The cerebellum is at a greater or smaller distance from the bigeminal or quadrigeminal bodies. This accounts for the different lengths of the part styled valve of Vieussens, which consists of a thin slip of fibres running transversely between the cerebellum, the edges of the primary bundles that expand into the organs of the affective faculties, and the bigeminal or quadrigeminal bodies. (Pl. xi. fig. 1, *y*.)

To shew the interior of the fourth ventricle, the union of the two cerebellar hemispheres, and

the Vieussenian valve in man and the mammalia, the brain must be laid on its superior surface (pl. vi. fig. 1), the annular protuberance and the medulla oblongata separated, and the two halves pushed aside.

In fishes there is scarcely a part analogous to the valve of Vieussens. This happens from the vicinity of the cerebellum and the other ganglions. In birds, however, the part is very distinct. (Pl. iii. fig. 6, and pl. xi. fig. 3, *y*.)

Behind the bigeminal bodies in birds (pl. xi. fig. 3), and the quadrigeminal bodies in the mammalia and man (pl. xi. fig. 1), at the point where the nerve of the superior oblique eye-muscles goes off (ibid. 13), there is a transverse uniting band.

The bigeminal or quadrigeminal bodies are always united by commissures or transverse bands. (Pl. iii. fig. 6, and pl. xi. fig. 1, 2, 3, *x*.) The body called pineal gland is always found in animals possessed of the great inferior ganglion of the brain (thalamus). I do not believe that it occurs among fishes. M. Tiedemann entertains the same opinion; but M. Serres * declares, that the pineal gland is to be demonstrated in all the four classes of vertebral animals. According to him, the body has two sets of peduncles, one issuing from the optic thalamus, another from

* Rapport, &c., p. 69, 70.

the quadrigeminal tubercles. He, however, is in evident contradiction with himself when he adds, that the thalamus does not exist in fishes.

Anatomists now-a-days are agreed as to the part in question being no gland, but a nervous mass composed of white and cineritious substance. Its form and size vary extremely in different classes of animals. It always lies between the true optic and the great inferior ganglions of the brain. It has four connecting slips, two on either side. The posterior pair run backwards and downwards, and adhere to the proper ganglions of the optic nerves. (Pl. vii. fig. 2, and pl. x. fig. 1, B. ε.)

It is at the fore-part of the pineal gland that the granular concretions which have attracted so much notice are principally found. Malacarne * says, that he has seen them in the pineal gland of a goat, and Sœmmerring †, that he has detected them in that of a fallow deer.

Des Cartes is generally known to have considered the pineal gland as the seat of the soul. At the present day, it were useless to repeat the arguments that Steno ‡ has employed against the Cartesians in refutation of their error.

I only speak of the pineal gland in this place

* Encephalotomia di alcuni Quadrupedi, Mantua, 1795.

† Vom Hirn und Rückenmark, Maynz, 1788.

‡ Discourse on the Anatomy of the Brain, inserted in Winslow's Anatomy.

for the sake of connexion, for it appears to belong, at least, as much to the instruments of communication as to those of union.

The part which, by anatomists, is entitled posterior commissure, is found lying anteriorly to the proper optic ganglion, and at the commencement of the great inferior ganglion of the brain, into which it plunges immediately. (Pl. iii. fig. 9, pl. vii. fig. 2, and pl. xi. fig. 1, ν.)

The transverse fibres, usually termed the soft or middle commissure, may be readily seen extending between the great inferior cerebral ganglions in the mammalia. (Pl. xi. fig. 1, 46.) Many authors have doubted the existence of this part in man. It may unquestionably be demonstrated in the human brain, but its very delicate fibres are easily torn, and care is required in the attempt to point it out. But it may be most readily shewn from below by separating the crura, the annular protuberance, and the medulla oblongata.

I now come to a commissure that is quite constant in all vertebral animals. In man, it is called the anterior commissure. Its regular occurrence, like that of the posterior commissure and uniting fibres of the quadrigeminal or bigeminal bodies, is an index of its importance. In the eel (pl. ii. fig. 1), and barbel (ib. figs. 12 and 13), it lies between the second pair of ganglions, beginning the reckoning from before (ib. fig. 13, 61); in the flounder (ib. fig. 4), the roach (ib. fig. 11), and others, it

is situated between the olfactory ganglions. In all the animals possessed of striated bodies, viz. reptiles, birds, and the mammalia, it always lies anteriorly to the junction of the optic nerves. It traverses the striated bodies, and is continued onwards between the anterior and middle lobes. (Pl. iii. figs. 6 and 9; pl. viii. figs. 1 and 2, and pl. xi. figs. 1 and 2, 61.)

In all the mammalia, the anterior commissure is composed of two parts: the one of these communicates with the olfactory nerve, the other, as in man, is prolonged towards the fissure of Sylvius between the anterior and middle lobes. This discovery I published in the spring of 1821, in a thesis, entitled *Encephalotomie* *. The portion running to the olfactory nerve forms an arc, the convexity of which is turned backwards, the concavity forwards. (Pl. iv. fig. 4, 31.)

In man, the anterior commissure traverses the exterior half of the striated bodies; it communicates first with the innermost convolutions of the anterior lobes, then with those situated at the bottom of the Sylvian fissure, and lastly, with those in the fore part of the middle lobe. It thus forms an arc, whose longest and concave edge is directed backwards. (Pl. viii. fig. 2, 61.)

M. Chaussier † and M. Tiedemann ‡, regard the anterior commissure as a continuation of

* Vide p. 23. † Anatomie du Cerveau, p. 71.
‡ Op. cit., p. 138.

the cerebral crura. Anatomy exposes this error. Having laid the brain on its superior surface, (pl. vi. fig. 1, and pl. viii. fig. 2,) turn back the optic nerves and separate the hemispheres slightly, a white cord about the thickness of a writing-pen will be brought into view. Remove the superimposed parts without implicating the anterior commissure itself, and its passage across the striated bodies will be distinctly perceived. Arrived at the anterior extremity of the middle lobes, the anterior commissure divides into a great number of filaments that communicate with the convolutions. I shall bring this section to a close, by proposing the following question:—Is the anterior commissure proportionate to the cerebral masses destined to the intellectual faculties?

Section VIII.

Of the Communications of the Nervous Apparatuses.

Thus far advanced, we have seen that the nervous system is an aggregation of organs performing special functions; that the instruments of phrenic life exist in pairs, and that there is a particular structure, by which congenerate parts are united. Another essential consideration refers to the communication with each other of the peculiar nervous apparatuses, an arrangement which is indispensable to account for the mutual influence, or, as it is termed, the sympathies of the functions.

The functions of the thoracic and abdominal viscera are evidently mutually influential, and the nerves of vegetative life, generally, communicate together. Again, vegetative and phrenic life are mutually related; imperfect digestion, for example, disturbs the intellectual energies, and excessive mental application, or moral sadness, interrupts the process of digestion. The communications between the nerves of the thorax and abdomen, and the anterior roots of the spinal and cranial nerves, especially the pneumogastric, the hypoglossal, the abductor, the facial, and the trigeminal, are well known anatomical facts.

Further, the spinal nerves are intimately con-

nected with each other; there are longitudinal bands that run along the edges of the two fissures of the spinal cord; these are, especially, evident on the dorsal aspect of the cervical portion (pl. i. fig. 5.), and on each side, at the bottom of the dorsal fissure. (Pl. i. fig. 7.) The nerves of voluntary motion and of sensation are also most intimately connected.

Moreover the nerves of motion, of general sensation, and of the various special sensations, taste, smell, hearing, and sight, communicate with each other.

The mutual influence of the organs of motion, of the external senses, and of the affective and intellectual faculties, equally require an organic communication. The physiological experiments or mutilations which have been made in reference to this subject, are not, by any means, satisfactory. The cerebellum, which, according to M. Rolando, gives the locomotive power, and to M. Flourens, regulates the motions, is in more intimate connexion with the dorsal than with the abdominal roots of the spinal nerves; yet M. Magendie has been led to conclude that the dorsal roots of these nerves preside over sensation, whilst the abdominal are the special organs of motion. It is, however, certain that the external senses and the organs of motion, aid, to a greater or less amount, the cerebral functions, properly so called. It is to this end, consequently, that the nervous

masses of motion, and those of general and special sensation, communicate with the organs of the affective and intellectual faculties. This communication is established by means of the medulla oblongata, the decussation of some of whose component bundles, explains the effects of cerebral injuries being frequently manifested on the side of the body opposite to that on which they occur.

The sense of taste is subservient to the functions of digestion and nutrition, and its instrument is a branch of the trigeminal, a nerve of general sensation, supplying the organs of mastication, and arising very nearly from the same place as the glossopharyngeal, the pneumogastric and the facial.

The auditory nerve embraces the primary bundles of the organs of the affective powers, and these it assists more generally, especially among animals, than those of the intellectual faculties: males and females call on each other as the season of love draws near; the cries of the young bring the mother to their aid; the barking of the dog, the grunting of the hog, the crying of the monkey, collect other individuals of their several kinds to render assistance; all the animals that plant sentinels, know the sounds of alarm; and the courage, secretiveness, or circumspection of many species is excited by peculiar tones, appreciated by the sense of hearing. The cock taunts his adversary

by crowing; the sparrow, turkey, common fowl, and many other kinds of birds advise their young of an enemy's approach, and by their cries admonish them to keep quiet, or to seek security by flight.

The optic nerve aids almost all the affective and intellectual faculties. Instead of running directly from its origin to the eye, it therefore turns outwardly, and, in its course, communicates with all the parts adjacent, from its ganglion, onwards, to the tuber cinereum; so that in order to turn it back in man, it must be torn away from a thin communicating layer all the way along its outer edge as far as the external geniculated body. Phrenology shews that vision assists more immediately those organs situated backwardly, laterally, and anteriorly, than those in the middle line of the head, such as veneration, firmness, hope, justice, &c. In all animals, the optic nerve is, evidently, connected with a great number of cerebral masses.

The nerve of smell always communicates with the anterior cerebral lobes, and in animals this sense aids in a very particular manner the faculties that know external objects, their qualities, their relations, and the phenomena they present. Animals examine their food, their friends, their enemies, their dwellings, &c. &c., by means of smell.

The olfactory nerve also communicates with the anterior convolutions of the middle lobes,

especially with the part that corresponds to the hippocampus's foot, or the ammons' horn. If there be a cerebral part presiding over the functions of hunger and thirst, it would appear to be situated in this neighbourhood. I am confirmed in this supposition by the vicinity of the organ of destructiveness.

To conclude, nature has taken great pains to establish an intimate connexion between the different cerebral parts themselves. Two longitudinal bands, running at the bottom of the dorsal fissure of the spinal cord, are continued into the fourth ventricle. In fishes they run as far as the olfactory ganglions. (Pl. ii. fig. 13.)

The cerebellum, as I have already shewn, always communicates with the medulla oblongata, and the bigeminal or quadrigeminal bodies.

The parts successively added to form the cerebral hemispheres are connected together by transverse bands or interlacing fibres. A band of this nature is sometimes seen below the olivary bodies. (Pl. viii. fig. 2, 64.) Different other transverse interlacements are visible in every human brain that is moderately consistent, 1st, at the superior edge of the annular protuberance (pl. viii. fig. 1, 33); 2ndly, in the middle of the cerebral crura (pl. vi. fig. 1, and pl. viii. fig. 1, 34); 3rdly, below the optic nerve (ib. fig. 1, 35); 4thly, at the place where the fibres issue to enter the superior convolutions of the middle lobe

(pl. viii. fig. 1, 36); 5thly, between the two great cerebral ganglions (ibid. 37); 6thly, at the external edge of the striated bodies (pl. viii. fig. 1, and pl. ix. fig. 1, 38). These interlacing bundles do not occur on the external surfaces only, they also penetrate the interior of the masses to which they belong.

The greater part of the fornix, that is to say, the fimbriated bodies running from the hippocampus's foot, the posterior and anterior pillars, and the longitudinal fibres between them, as also the mammillary bodies and their prolongations, are evidently apparatuses of communication. (Pl. x. fig. 1, B. 57—62.) The anterior pillars of the fornix traverse the tuber cinereum, and plunge into the mammillary bodies, from whence another bundle issues, to be lost in the great ganglion of the organs of the affective faculties (thalami). (Pl. x. fig. 1, 16.) In the mammalia the fornix further communicates with the two longitudinal bands of the corpus callosum (raphé), and with the septum lucidum, which last in its turn communicates with the raphé, and with a band lying before the optic nerves. (Ibid. 57, 58, 59.) The raphé itself, and also the semicircular tape-worm of Haller (pl. xi. fig. 1, A. 32), appear to be instruments of communication, the first between the converging fibres themselves, the other between the great cerebral ganglions and the converging fibres.

These parts are strikingly analogous in all the

mammalia. In birds and reptiles there are fibres, which, from the middle lobes, the contours of the posterior lobes, and from the median line, come together towards the base of the brain, and form a bundle that communicates with the cerebral crura behind the optic nerves. This fibrous layer, or bundle of birds, consequently, resembles the fornix and septum lucidum of mammalia. (Pl. iii. fig. 6, and pl. xi. fig. 3, B. 60.)

In fishes, besides the two longitudinal bands that run the whole length of the encephalic masses, each ganglion sends a slip of communication to its neighbour, the cerebellum to the optic ganglion, this to the succeeding one, and so on successively, whilst the most anterior of all sends fibres to join the common longitudinal band of the olfactory nerves. (Pl. ii. fig. 13.)

The mass entitled infundibulum lies behind the junction of the optic nerves. It is evidently traversed by white filaments, and communicates with the tuber cinereum. (Pl. ii. fig. 4, 6, 8; pl. iii. fig. 12; and pl. vi. fig. 1, 17.)

The influence of the anterior pyramidal bodies on the propagation of the will, towards the instruments of motion, deserves some attention. According to phrenological observations, the anterior lobes of the brain contain the organs of the perceptive and reflective intellectual faculties, without which there would be no will *. Now these

* See Philosophical Principles of Phrenology, Lond. 1825, p. 32.

lobes are intimately connected with the pyramidal bodies, and these last communicate directly with the abdominal half of the spinal cord, whence, as it appears, the nerves especially appropriated to propagate the will are detached.

Lastly, in the animals whose brains are smooth on the surface, the peripheral connexion of the individual organs is manifest; in the other kinds, whose brains are convoluted, it is extremely interesting to trace the connexion of the different cerebral masses composing special instruments. These connexions explain the mutual influence of the faculties. The organs of analogous powers are regularly in each other's vicinity; the convolutions that compose them even run into each other. The organ of philoprogenitiveness communicates with that of inhabitiveness, and with that of courage; the organ of courage also communicates with that of attachment, and with that of destructiveness; the organ of secretiveness communicates immediately with that of destructiveness, and with that of circumspection; the organ of benevolence communicates with the organ of veneration; the organ of firmness is in communication with those of all the faculties around it—veneration, justice, and self-esteem; the organ of justice runs into that of the love of acquiring—this is connected with that of construction; the organs of the perceptive faculties are all linked together, as are those of the reflective powers in

like manner; the organ of artificial language is placed across the organs of the intellectual faculties generally. Thus, the especial pains which nature has taken to establish communications between the cerebral parts cannot be overlooked; and, as I have already said, it is this arrangement that enables us to understand the mutual influence of their functions respectively.

Section IX.

Of the Anatomico-Physiological Relations of the Nervous Apparatuses.

In Phrenology it is an admitted axiom, that structure does not reveal function; still, it is certain that there is a relation between the organic structure of an apparatus and its functions. Many considerations bearing upon this point are contained in the works which Dr. Gall and I have published conjointly as well as severally. In this place it will be enough merely to refresh the reader's memory.

No affective or intellectual function is ever manifested without a brain; and these functions appear simultaneously with the brain: this organ is in the first instance pulpy, it increases in growth, becomes fibrous, and advances gradually to its maturity; but after the meridian of life has been passed it shrinks again, and the convolutions become less plump, and seem less firmly packed than in youth and manhood's prime. The nerves also decrease in old age. The cerebral fibres in declining years acquire density and firmness, but they lose in specific gravity. In conformity with these facts, the mental faculties of newly-born children are confined to voluntary motion, to the

sensation of hunger, and to some obscure feelings of pain; by slow degrees the functions of the external senses become perfect; the child begins to attend to outward objects, to act upon these, to manifest determinate desires and clear notions; it becomes in succession boy, youth, and man, when the faculties shew themselves in their utmost energy; little by little they now begin to lose strength, and old age is at length marked by blunted sensibilities, and enfeebled intellectual powers. A defective development of the brain prevents the exhibition of affective and intellectual faculties, and causes idiotism. Men of great and general abilities have always a voluminous brain. Different cerebral parts are differently developed in the two sexes, in different nations, and in different individuals of the same people. The cerebral organization is oftentimes alike in several of the members of a family. In all these cases it is easy to prove a relation between the condition of the brain and the affective and intellectual manifestations.

The brains of different species of animals vary in density, in texture, and probably in their general organic constitution. This is the reason why functions essentially similar offer so many modifications, and never correspond in degree of energy with that of the development of their instruments: that is to say, the affective and intellectual aptitudes cannot be measured by the

absolute size of their organic apparatuses. Size, however, is one condition essential to energy; and other conditions being equal, the largest organs will shew the greatest vigour.

It would appear that, in conformity with the law established in regard to electrical phenomena, the energy of nervous apparatuses depends in a great measure on their quantity of surface, more on this, perhaps, than on their component quantity of nervous matter. M. Desmoulins, in his Memoir to the Academy of Sciences of Paris, attempts to prove, 1st, that integrity of surface is the only constant condition for the production of nervous actions; 2nd, that the intensity and perfection of nervous actions depend on the proportionate extent of nervous surfaces; and 3rd, that the nervous actions are performed and transmitted by the surface.

I do not mean to say that the quantity of a nervous apparatus has no influence on the energy of its functions; but the influence of the peripheral expansion is certainly great. May it be, on this account, that the cerebral apparatuses are hollow or lamellated? In the inferior classes of animals, the nervous masses are very commonly hollow.

Cavities and anfractuosities unquestionably increase the surface of organs. Have the annular protuberance and corpus callosum of man and the mammalia a like destination? The cavities and

convolutions also facilitate the circulation of the blood, and thus appear to produce twofold good effects.

Let us turn, then, and examine the cerebral cavities and their communications. The common number of cavities reckoned is four. The fourth is formed by the separation between the cerebellum and medulla oblongata. (Pl. ii. fig. 13; pl. vii. fig. 2; pl. x. fig. 1; pl. xi. figs. 1 and 3, *m.*) The dimensions and development of the fourth ventricle, says M. Desmoulins, coincides with the development of the eighth pair of nerves. Now to me the fourth ventricle seems nothing in itself, and not at all proportionate either to the cerebellum, or the eighth pair of nerves. It, in fact, depends entirely for its size on the united breadth of the medulla oblongata and development of the cerebellum. Is the cerebellum broad and the medulla oblongata narrow, the fourth ventricle will be narrower than it would have been, were the medulla and cerebellum both broad. In the sturgeon, frog, toad, &c., the fourth ventricle is of considerable magnitude, and the cerebellum very small.

The fourth ventricle runs between the annular protuberance and valve of Vieussens on to the aqueduct of Sylvius, or canal between the crura of the brain and the commissure of the quadrigeminal bodies. (Pl. vii. fig. 2, ϕ; pl. x. fig. 1, ϕ.) This canal (*iter à quarto ad tertium ventriculum*) then

opens into the third cerebral ventricle, or separation between the great ganglions of the affective faculties. (Pl. xi. fig. 1, M.)

The third ventricle communicates on both sides of the median line by the cleft between the fornix and the great ganglions of the affective powers (pl. x. fig. 1), with the lateral cavities which extend into the anterior, posterior, and middle lobes.

The communication between the lateral cavities of the brain and the third ventricle is thus established, and not by a natural opening, styled foramen Monroi, nor by any supposed rupture of the septum lucidum.

Having placed the brain on its superior surface, and cut through the optic nerves, the crura, the annular protuberance, and medulla oblongata at their junction in the median line, and separated the two halves, an opening will be seen between the anterior pillar of the fornix and the great inferior ganglion of the brain. This opening, just described, was called a foramen, by Dr. Monro of Edinburgh, and anatomists have entitled it foramen Monroianum. It is, as we have seen, no true foramen or hole, but a mere part of the great cleft that brings the third ventricle into communication with the great lateral cavities.

From this peculiar structure of the cerebral cavities, it must appear evident that a great accu-

mulation of water can never be found in one hemisphere only. A small quantity may undoubtedly be collected in the lateral and posterior parts of one of the great ventricles; but, whenever it becomes considerable, it raises the fornix, flows into the third ventricle, and from this immediately gains the cavity of the opposite side. All the observations which have been made are consistent in this particular. The large hydrocephalic crania preserved in museums prove universally that both hemispheres have been distended.

Some anatomists speak of a fifth ventricle between the two layers of which the septum lucidum consists; but in this sense every anfractuosity may be called ventricle.

M. Serres* is much mistaken when he maintains that in fishes, reptiles, and birds, there is no ventricle, and that the brain is a solid mass. In fishes each ganglion is hollow; and in reptiles and birds there is a cavity between the striated bodies (the great cerebral ganglions) and the fibrous band, precisely as there is one in the mammalia between the two cerebral ganglions, the fornix, and the septum lucidum. (Pl. xi. figs. 2 and 3.)

Here it will not be out of place to take a general and cursory view of what are entitled physiological experiments; the means which, in

* Rapport, p. 77.

the eyes of experimenters, ought to establish and confirm the physiology of the nervous system in general, and of the brain and its parts in particular. Dr. Gall and I have always declared against such violent means of obtaining conclusions. We prefer observing the relations between the development of different parts and the exhibition of particular functions, and investigating pathological facts. However, I do not incline to neglect any means, whatever its nature; I conceive that it is a great mistake to confine inquiries within any one particular channel. Mr. Charles Bell regards anatomical research as the means the most favourable to the progress of physiology; Messrs. Magendie, Flourens, and others, on the contrary, prefer physiological experiments, in other words, mutilations; whilst M. Lallemand, again, seems to give the preference to pathological observations. Pathological cases appear to have been more fertile hitherto in results both anatomically and physiologically, than mutilations. Observing, for example, that the effects of the lesion of one side of the brain were proclaimed on the opposite side of the body, the decussation of the anterior pyramidal bodies was sought for and discovered. Observing that great distention of the cerebral hemispheres did not impede affective and intellectual manifestations, the structure of the convolutions was inquired into and demonstrated. Remarking that

sensibility may be lost without the powers of motion suffering, and that the power of locomotion may be lost without that of sensation being disturbed, researches on the nerves of these two sorts of functions have been instituted, and so on. Pathological facts, however, cannot be interpreted in opposition to physiological observations. Will any one say with M. Foville, that the superficial substance of the brain presides over the intellectual functions, and the white and deep-seated masses of gray substance over locomotion, because he has observed that derangements of these two orders of functions accompanied organic alterations of the superfices, or internal parts of the brain? Will any one say again, with Messrs. Foville and Serres, that the great ganglion of the affective faculties (thalamus) and its white fibres are in relation to the motion of the arm and the ganglion of the intellectual faculties (corpus striatum) and its radiating fibres to the motion of the leg? Is it not necessary, before such a proposition be received as correct, to prove physiological observations in harmony with these pathological cases? This, however, has not and cannot be done: hence there cannot possibly be any truth in the above surmises.

Physiological experiments would tend to the establishment of yet more extraordinary ideas. M. Magendie pretends, that without the trigeminal nerve (fifth pair), we could neither hear,

nor see, nor smell; that the cerebellum is necessary to precision in all movements forward, as every severe wound of the cerebellum renders motion in this direction impossible; that the crura of the brain, the quadrigeminal tubercles, the pretended thalami, and the striated bodies, have all functions relative to motion; lastly, that the nerves arising from the posterior roots of the spinal cord belong to sensation, and those of the anterior roots to motion, whilst M. Bellingeri * says, that *his* experiments lead him to conclude that the function of the posterior roots is motion, especially motion of extension, and not sensation. He thought he could confidently advance, that when feeling only was paralyzed, the seat of the disorder was in the cineritious substance; that in palsy of the locomotive powers without loss of feeling, the disease was exclusively in the white substance; and that in palsy of both functions the two substances were altered at the place where the nerves distributed to the affected parts arise. In fine, if the loss of motion be a more frequent symptom than the loss of feeling, this, according to our author, happens from the white substance being situated on the outside of the spinal cord, and consequently, in his estimation, being more exposed than the gray to the action of external agents.

The cerebellum, by the experiments of M.

* Mem. dell' Academia delle Scienze di Torino, tom. 30.

Rolando, is made out an electrometer, or sort of voltaic pile, and the sole source of a fluid that excites motion; whilst M. Flourens, by his experiments discovers that the cerebellum is the balancer, or governor, or regulator of voluntary motion.

In the opinion of some experimenters, the quadrigeminal tubercles are the seat of vision; but M. Flourens is led to consider them as the simple conductors of vision, which is not changed into perception but in the brain itself, because he found that on cutting away a lobe, he produced blindness of the opposite eye.

The medulla oblongata, according to M. Flourens, is the central magazine, the vital knot of the nervous system, to which all impressions must come, to be appreciated; from which the commands of the will must emanate, to be executed; to which it is sufficient for parts to be attached, in order to live, and from which to be detached, is sufficient cause of death. But M. Fodera, from *his* experiments, believes that the medulla oblongata is the seat of dozing and of sleep; he even accords to this part of the encephalon, some influence on the production of moral phenomena.

Lastly, according to M. Flourens, the brain includes sensibility and will; without brain, no sensation, no will. M. Rolando observed that dozing and stupidity supervened each time he

cut away the cerebral lobes. He conceives the brain to be, at once, the seat of the sensitive and intellectual faculties, and the agent of the cerebellum's regulating and directing power on the motions, an agent, however, which cannot influence the motions without the cerebellum, their immediate cause.

The reader must have felt the jarring and contradictory nature, and insufficiency of the preceding opinions. They do not appear to me worthy of any detailed refutation. Their contradictions bespeak clearly enough their falsity. I do not deny the facts, as they are reported by the experimenters, but I think these gentlemen over-eager and too ready to draw conclusions: I see them unapt to distinguish between facts and their causes, between primary and secondary causes, and to separate powers and conditions to activity from actions. I also think that they neglect the mutual influence of the several instruments too much; and that they frequently attribute to one condition, that which belongs to several. The trigeminal nerve aids the nerve of vision, but the optic nerve is the instrument of sight; the olfactory nerve is assisted in its office by the nerves of inspiration, of the nostrils, but it alone procures the special sensation we entitle smell.

These physiological experiments or mutilations, would reduce the functions of the spino-cerebral system to a very small compass; and it is but

natural that I should declare for the physiological observations made in the state of health, by considering the relation between the development of special organs, and the energy of peculiar manifestations. These observations are collected, and their results proclaimed in the volume entitled Phrenology.

I conclude this treatise by repeating, that the anatomical knowledge of the nervous system in general, and of the brain in particular, must be in harmony with physiology and pathology; and that any one of these three departments must be modified whenever there is contradiction in reference to any of the others.

EXPLANATION

OF

THE PLATES AND FIGURES.

Plate I.

Fig. 1. Four ganglions, with their branches of communication, of the caudal extremity of a caterpillar. This arrangement of the nervous system reigns through the entire length of the body of caterpillars and worms.

Fig. 2. The caudal extremity of the spinal marrow of a fowl, with the origin of the three last pairs of dorsal nerves.

Fig. 3. The three superior cervical pairs of nerves in a calf, seen on the abdominal surface. The dura mater and arachnoid are slit longitudinally and turned aside, so as to expose the mode in which the nervous filaments come from the common mass, their different directions, and the passage of the bundles through the dura mater. The commencement of the intervertebral ganglions (*a*) is covered by the reflected membranes. Between the different pairs of nerves, the teeth of the ligamentum dentatum (*b*) are seen on each side of the nervous mass; these ligaments separate the abdominal from the dorsal roots, and are attached to the dura mater by means of slips, naturally different in size and position. At the origin of each pair of nerves, a swelling is perceivable, varying in magnitude, in proportion to the volume of the issuing nerve. The

direction of the nervous fibres from before backwards, and from behind forwards, is evident.

2, 3. The accessory nerve.

5. Median abdominal fissure.

Fig. 4. The four superior cervical pairs f nerves in man, seen from before.

Fig. 5. The five superior cervical pairs of nerves in man, seen from behind.

The membranes, ligamentum dentatum, accessory nerve, intervertebral ganglions, bulgings and contractions of the nervous mass, are, absolutely, the same as in Fig. 3. On the dorsal surface there are, frequently, fibres of communication from one pair of nerves to the other, for instance, between the fourth and fifth pairs.

Fig. 4. 5—5. Median abdominal fissure.

Fig. 5. 5—5. Median dorsal fissure.

α—α. Lateral dorsal channels.

Fig. 6. The edges of the two abdominal halves separated, permitting a view of the structure at the bottom of the abdominal fissure.

β—β. Lateral cords.

ϑ—ϑ. Apparatus of union of the two halves situated at the bottom of the abdominal fissure.

Fig. 7. The edges of the two dorsal halves, separated, permitting a view of the structure at the bottom of the dorsal fissure.

β—β. Lateral edges.

ϑ—ϑ. Apparatus of union of the two halves situated at the bottom of the dorsal fissure.

Fig. 8. Transverse section of the cervical nervous mass of a carp.

Fig. 9. Transverse section of the cervical nervous mass of a fowl.

Fig. 10. Transverse section of the cervical nervous mass of a man.

In the three last figures, the general type is the same: two halves of the spinal cord; two median fissures, an anterior and a posterior.

δ. Exit of the abdominal roots of the nerves.

η. Exit of the dorsal roots of the nerves.

Plate II.—*Brains of Fishes.*

Fig. 1. The brain of an eel seen from above.

Fig. 2. The brain of a cod seen from above.

Fig. 3. The brain of a skate seen from above.

Fig. 4. The brain of a carp seen from below.

Fig. 5. The brain of a carp seen from above.

Fig. 6. The brain of a flounder seen from below.

Fig. 7. The brain of a flounder seen from above.

Fig. 8. The brain of a cod seen from below.

Fig. 9. The optic nerves in the cod are thrown back, to permit a view of the two roots of the olfactory nerves.

Fig. 10. The brain of a pike, with the cavity of the optic ganglion exposed.

Fig. 11. The brain of a roach.

Fig. 12. The brain of a barbel seen from above.

Fig. 13. The interior of the brain of a barbel, prepared to permit a view of the ganglions, their communications, and junctions.

Plate III.—*Brains of Reptiles and of Birds.*

Fig. 1. The spino-cerebral system of a frog seen from below.

Fig. 2. The brain of a frog seen from above.

Fig. 3. From M. Carus's work.—The brain of a lizard (lacerta iguana) seen from above.

Fig. 4. From M. Carus's work.—The brain of a young crocodile seen from above.

Fig. 5. The brain of a common fowl seen from above.

Fig. 6. The brain of a fowl.—The two hemispheres separated to shew the cerebellum, the optic ganglions, their commissure, the commencement of the supposed optic thalami, and the part analogous to the fornix of the mammalia.

Fig. 7. The brain of a turkey seen from above.

Fig. 8. The brain of a turkey with the cerebellum cleft posteriorly, to shew its lamellar structure.

Fig. 9. The brain of a common fowl, prepared to shew the cavity of the optic ganglion, the posterior commissure, *v.*; the beginning and continuation of the great cerebral ganglions.

Fig. 10. The brain of a duck seen from above.

Fig. 11. The brain of a goose seen from above.

Fig. 12. The brain of a goose seen from below.

Plate IV.—*Brains of Mammiferous Animals.*

Fig. 1. The brain of myrmesophaga didactyla seen from above, copied from the work of Tiedemann.

Fig. 2. The brain of a hare seen from below.

Fig. 3. The brain of a hare seen from above.

Fig. 4. The brain of a hare placed on its upper surface, like Fig 2; the mass below the crura cerebri is cut off; the crura are separated and pushed sidewards, to see the under surface of the posterior lobes; the fornix, 60; the posterior fold of the corpus callosum, 40; the anterior pillar of the fornix γ; the anterior commissure, 61, and its two portions.

Fig. 5. The brain of a cat seen from above.

Fig. 6. The brain of a dog seen from above. All parts are reduced to the fourth of their natural size.

Plate V.

[The brains and their parts, represented in this plate, and all preparations of the human brain, in the following plates, are only a fourth of their natural size.]

Fig. 1. The brain of the monkey, simia sabœa, seen from above.

Fig. 2. The brain of the monkey, simia capucina, seen from above.

Fig. 3. The brain of the ourang-outang seen from below.

Fig. 4. The brain of the ourang-outang seen from the right side.

Fig. 5. The brain of an idiotic girl seen from below.

Fig. 6. The same brain of the idiotic girl seen from the right side.

Plate VI.

Fig. 1. The basis of the human brain.—All the parts are in pairs, but not quite symmetrical. The brain is taken from the skull, and turned on its upper surface; the cerebellum and medulla oblongata have fallen backwards; the different investing membranes are removed; the cerebral and nervous masses alone are visible.

To take the human brain from the skull, I make an incision from one ear to the other, turn the integuments backwards and forwards, and detach the temporal muscles from the bone. If it is requisite to preserve the skull, it must be sawed about three-quarters of an inch above the superciliary ridge, round on each side to the middle of the occipital bone; if it be no object to keep the skull

entire, Bichat's plan, which is much easier and more speedily accomplished, may be followed; it consists in using the sharp edge of a hammer along the course indicated, and breaking instead of sawing the skull. In this way infinitely less risk is run of injuring the membranes and cerebral convolutions than when the saw is employed. There then usually issues a greater quantity of fluid from between the membranes, and from out of the vessels of the neck when they are divided, in consequence of the shaking the parts have undergone; the cerebral mass also sinks to a greater extent, and the dura mater does not look so tightly stretched over the convolutions, but the internal organization suffers no change.

When the skull-cap is removed, I cut the dura mater on each side of the longitudinal sinus before and behind, and transversely between the ears; I then turn down the flaps, detaching the falciform process of the dura mater in the frontal region, and turn it backwards. I now bring back the head, so that the base becomes the superior part; I support it with the left hand in the occipital region, and the brain then lies on the palm of the hand. Their own weight almost always suffices to detach the anterior and middle lobes from their places,—at the most, the slightest assistance from the fingers accomplishes this. The bulb of the olfactory nerve generally separates from the ethmoid bone of itself, or the handle of the scalpel detaches it with ease. The optic nerves, the infundibulum, the oculo-motors, the abductor nerves of the eye, the nerves of the superior oblique, and the trigeminal pair, must be cut in succession; I now depress the head upon the hand, first on one, then on the other side, pushing at each time the hemispheres from the tentorium, in order to cut this part across. After this, I detach the nervous pairs and

blood-vessels situated near the medulla oblongata; and, lastly, I cut the cervical nervous mass below the occipital hole, as low down as possible, not to damage the decussating fibres. I raise the cerebellum with the fingers of the right hand, and lift the entire cerebral mass from the cranium. There is one precaution that is very necessary to be taken, it is, to support the hemispheres with the flat of the hand properly, to prevent the crura from being torn before the tentorium is cut, and to guard against the same accident, in regard to the medulla oblongata below the annular protuberance.

A hammer or a saw, and two scalpels, the one to separate the integuments and the muscles, the other to cut the membranes and the nervous parts suffice for this operation. It is well to have the second scalpel long in the handle, to secure the cervical nervous mass being easily divided low enough down.

Fig. 2. A skull sawed vertically through the middle of the forehead, the vertex and the occiput, to expose the exterior and lateral surface of the brain, cerebellum, annular protuberance, and medulla oblongata in their natural situations. The bone here supports the cerebellum and medulla oblongata, whilst in Fig. 1 they had sunk downwards and backwards.

Plate VII.

Fig. 1. A skull sawed horizontally in a line from above the eye-brows, by the middle of the temples, and the upper part of the occipital bone. The membranes and blood-vessels are removed, and the two hemispheres are seen from above.

Fig. 2. The skull, brain, and cerebellum cut vertically

through the median line, and in their natural situations. In this preparation the various parts are retained in their proper places, not without considerable difficulty.

Plate VIII.

Fig. 1. A preparation exhibiting various parts about the base of the brain.

Side B. The hemisphere of the cerebellum entire; its primary bundle is seen to plunge between the facial nerve, 11, and the auditory nerve, 9. The trigeminal nerve, 12, is entirely covered by the transverse fibres of the cerebellum; the olivary body, *a*, plunges through the transverse fibres of the cerebellum; a portion of the transverse mass is removed to exhibit the course of the pyramidal bundle, 1—*c*, which begins to diverge and to be augmented. The optic nerve is in its natural position; on its outer edge the expansion of the nervous bundles, *W*, *W*, *W*, in the inferior convolutions of the middle lobe, is seen.

Side A. A vertical section of the cerebellum guided through the entrance of its primary bundle, and the middle of its ganglion, *s*, shewing the augmentation of the primary bundle in the ganglion, and the ramifications and subdivisions of the nervous cords. All the transverse fibres of the annular protuberance, which cover the trigeminal nerve, and the prolongation of the pyramidal bundle, are cut away. The continuation of the olivary body, *a*, is still covered by the transverse bundles. The optic nerve is raised from the crura, *g*, and cut across at *q*. The pyramidal bundle is thus exposed from the decussation, 1, to the transverse interlacement beneath the optic nerve. The mass of gray substance seen on the opposite side has been scraped off, in order to expose the

two cords of the mammillary bodies, 16, the one near the transverse interlacement, 35, the other towards the fornix. The nervous fibres that expand in the convolutions, and contribute to their formation, are cut at *h*, *h*, between 35 and 37, on a level with the anterior commissure, and the middle lobe is removed altogether. The mass of gray substance of the great superior cerebral ganglion (striated body), and a part of the convolutions lying at the bottom of the great fissure, *D*, between the anterior and middle lobes, are incised in the same direction The way in which this collection of gray substance is divided by the nervous bundles, *P*, at its internal, *l*, and its external, *L*, parts, the mode in which fine filaments traverse the external part of the gray mass, the manner in which the convolutions, 44—45, are formed by the posterior cords of the cerebral crura placed before *q*, and the length and the depth of the great fissure, between the anterior and middle lobes, are all exposed in this preparation. By the removal of the middle lobe, the side of the great lateral ventricle, *N*, has become visible. This ventricle is continued backwards, inwards, and forwards, below the crura of the brain, *g*. Only a small portion of the anterior lobe is cut off.

Fig. 2. The great commissure of the cerebellum (annular protuberance), *b*; the anterior commissure, and the commissure of the anterior lobe (the anterior fold of the corpus callosum), 39, are here represented.

Side A. The anterior edge of the cerebellum is removed by a vertical cut from within outwards, to expose the conveyance of the uniting fibres towards the median line; the middle and anterior lobes of the brain are entire; the optic nerve is turned back, to exhibit the augmentation it has received from the gray mass situated at its junction,

The communication of the white fibres, 63, before the optic nerve, and in front of the anterior commissure, 61, together with the septum lucidum, and the connexion of the olfactory nerve with the inferior convolutions of the anterior lobe, are also to be seen.

Side B. The lower portion of the cerebellum is removed by a horizontal incision, 65, which passes by the deep channel seen on side *A*.

To shew the anterior commissure, I cut the optic nerves at their junction, reflect their two extremities, and from the middle of the commissure I begin with the handle of the knife to remove all the parts that cover it, taking care to injure none of the fibres of the commissure itself. One part of the convolutions, the interior of which is called foot of the hippocampus, 29, and the anterior internal convolutions of the middle lobes, are cut off.

The brain has been left in the cranium, but as this has been cut away above the cerebellum, and a part of the posterior cerebral lobes, these masses have fallen out of their natural situations; and on the side *B*, the convolutions of the middle lobe have been pushed outwards, because the commissure was prepared from within outwards.

Plate IX.

Fig. 1. The cranium sawed on the right side; the cut passes vertically by the middle of the cerebral and cerebellar hemispheres, and by the right orbit. The great union of the cerebellum, *b*, is cut transversely behind the exit of the trigeminal nerve, and the external part of the cerebellum is removed. The cerebral parts which, in pl. viii. fig. 1, were situated between the transverse interlacement, 35, and the nervous bundles, P, are taken

away, so as to permit a view of the divergeance of the fibres in all directions.

By comparing this figure with the first figure of pl. viii. the different appearances of the same parts prepared in their situations, with the support of the cranium, and deprived of this by being taken out of the skull, will be appreciated.

Fig. 2. The cranium sawed perpendicularly in the middle line of the head. All the parts which are seen in pl. vii. fig. 2, even to the convolutions, indicated by Roman letters, are here removed by cutting or scraping, in order to shew the passage of the pyramidal bodies, 1—*c*, across the annular protuberance, *f*, the augmentation of the diverging bundles in the great inferior ganglion (optic thalamus) *p*, and the course of the bundles which issue from them.

The course of the bundles, which communicate directly with the anterior pyramids, is principally shewn in fig. 1; whilst the manner in which the internal and posterior convolutions of the hemispheres are formed by the nervous fibres of the great inferior ganglion of the brain, (thalamus opticus,) is seen in fig. 2.

Plate X.

Fig. 1. The brain laid on its superior surface. The side B, exhibits the entire nervous mass of the brain and cerebellum, cleft in the median line from the medulla oblongata to the fornix, and laid on the side. The gray mass behind the junction of the optic nerves, and a small part of the pretended thalami have been scraped away, to expose the two internal cords of the mammillary bodies, 16, the one running towards the transparent septum,

57, 58, 59, the other plunging into the interior of the great inferior ganglion, *p*, *p*. Side A. The medulla oblongata and cerebellum are cut near the annular protuberance. At 30, a part of the median layer is removed, to expose the continuation of the oculo-motor nerve into the black substance. The posterior part of the great inferior ganglion, the half of the pineal gland with two cords, and the quadrigeminal bodies, are as on the opposite side B ; the anterior part of the great inferior ganglion is cut on, to shew the prolongation of the internal posterior cord of the mammillary bodies, with the transverse interlacement 36, pl. viii. ; the septum lucidum, the fornix, the internal portion of gray substance of the corpus striatum, and several internal convolutions of the posterior and middle lobes, are removed, to shew the great diverging bundles P, P, and the masses of union, known by the name of corpus callosum, in the great cerebral cavities N, N. The anterior 39, and the posterior 40, fold; and the raphé of this mass are perceived. The direction of the converging fibres from behind is forwards and inwards, from before backwards and inwards, and from the middle directly inwards. Lastly, the interlacing of the diverging bundles with the fibres of union is presented.

Fig. 2. The brain of a goose laid on its upper surface. Side B. The cerebellum and the hemisphere of the brain entire ; the medulla oblongata cleft along the median line, and one of its halves put aside.

Side A. The half of the medulla oblongata, its adherence to the cerebellum, and its continuation towards the brain at the crus are divided, to expose the communication between the cerebellum and the optic ganglion, which is hollow, and communicates from its anterior by means of a white layer with the brain.

Fig. 3. The brain of a goose laid on its superior surface. Side B. The half of the brain and medulla oblongata, as in B, fig. 2; but the inferior and posterior part of the cerebellum is here cleft, to exhibit its lamellar structure. The optic ganglion and the optic nerve are taken away to show the continuation of the anterior commissure, 61, and the entrance of the crus, *p*, into the hemisphere.

Plate XI.

Fig. 1. The human brain laid on its base; the primary part of the cerebellum and the corpus callosum are split along the median line. The posterior snrface of the medulla oblongata, the posterior pyramidal bodies, the primary bundles of the cerebellum, and a third portion of the restiform bodies, *e—e*; the interior of the fourth ventricle, *m*, the communication of the cerebellum, *y*, with the quadrigeminal bodies, *n*, *o*, and their union, *x*, the origin of the sympathetic nerve, 13, the pineal gland E, with its two anterior cords; the posterior commissure, *v*, the soft commissure, 46, and the anterior commissure, 61, cleft. On the side A, only the fornix and the septum lucidum are removed, to expose the striated bodies and thalami lying beneath. Side B. The primary bundle of the cerebellum and the parts, seen on the surface of side A, have been removed by a horizontal cut from within outwards, and from before backwards, on a level with the white fibres situated in the fourth ventricle, *t*. The internal portion of the anterior part of the brain has also been cut away by a vertical incision, in order to expose the division of the striated bodies into two parts, *l*, L, by the passage of the great bundles P.

This vertical cut is not made to begin more posteriorly, for fear of injuring the commissures visible along the median line. To exhibit the passage of the bundles from the medulla oblongata across the great ganglions, and the augmentation of the parts, the cut must be carried, pl. vi. fig. 1, through the middle of the anterior pyramidal bodies, 1—*c*, through the annular protuberance, *b*, the crura of the brain, *g*, in the direction of the organ IX.

Fig. 2 and 3. The brains of geese laid on their inferior surfaces. *Fig*. 3. Side B. The hemisphere of the brain put aside, and the cerebellum cleft along the median line, to shew its lamellar structure and internal cavity, 62. Side A. The optic ganglion exposed, *n*; a part of the crus and anterior internal portion of the brain to the junction of the optic nerves removed; part of the crus and of the striated bodies seen interiorly remaining.

Fig. 2. The cerebellum cleft along its inferior surface, and spread out on each side; the pretended optic thalami on both sides, *n*, and the striated bodies, *l*, *l*, on side A, are in the natural state; whilst on side B the radiated layer of cerebral substance is visible anteriorly, P; the anterior commissure, 61, is perceived in its full length. The posterior portion of the hemisphere, 60, untouched.

Explanation of the Signs in the Figures.

A and B. Sides of preparation.

D. Convolutions at the bottom of the figure of Sylvius.

E. Pineal gland.

L. External portion of the great superior ganglion, (striated body.)

M. Third ventricle.

N. Great lateral ventricles.

P. The bundles of the striated bodies.

a. Olivary bodies.

b. Annular protuberance.

c. Entrance of the anterior pyramids under the annular protuberance.

d. Transverse band below the pons Varolii in mammiferous animals.

e. Restiform bodies.

f. Passage of the anterior pyramids through the annular protuberance.

g. Peduncles of the brain.

h. Section of the bundles which go to the middle lobe.

i. Origin of the trigeminal nerve.

k. Exit of the trigeminal nerve.

l. Internal part of the great superior ganglion (striated body).

m. Fourth ventricle.

n. Anterior pair of the quadrigeminal bodies.

o. Posterior pair of the quadrigeminal bodies.

p. Great inferior ganglion (thalamus).

q. Corpus geniculatum externum.

r. Corpus geniculatum internum.

s. Ganglion of the cerebellum (corpus dentatum).

t. White fibres in the fourth ventricle.

u. Junction of the optic nerves.

v. Posterior commissure.

w. Fibres in communication with the external edge of the optic nerve.

x. Commissure of the quadrigeminal bodies.

y. Valve of Vieussenius.

α. Lateral fissure of the spinal cord.

β. Mesial edge of the spinal cord.
γ. Anterior pillar of the fornix.
δ. Abdominal root of the spinal nerves.
q. Dorsal root of the spinal nerves.
ϑ. Commissure of the spinal cord.
λ. Extremity of the corpus callosum.
μ. Middle part of the corpus callosum.
φ. Aqueduct of Sylvius.
1. Decussation of the anterior pyramids.
2—3. Accessory nerve.
4. Hypoglossal nerve.
5. Mesial fissure of the spinal cord.
6. Pneumogastrical nerve.
7. Glossopharyngeal nerve.
8. Ganglion of the auditory nerve.
9. Auditory nerve.
10. Abductor nerve.
11. Facial nerve.
12. Trigeminal nerve.
13. Superior oblique nerve.
14. Section of the annular protuberance.
15. Common oculo-motor nerve.
16. Mammillary body.
17. Cineritious tubercle.
18. External root of the olfactory nerve.
19. Middle root of the olfactory nerve.
20. Optic nerve.
21. Internal root of the olfactory nerve.
22. Infundibulum.
23. Bulb or ganglion of the olfactory nerve
25—26. Anterior lobe of the brain.
26—27. Middle lobe of the brain.
27—28. Posterior lobe of the brain.

29. Convolutions, which, viewed from within, form the pes hippocampi.

30. Black substance in the peduncles of the brain.

31. Commissure of the olfactory nerve in animals.

32. Semicircular band or tape-worm of Haller.

33. Transverse band at the upper edge of the annular protuberance.

34. Transverse band in the midst of the peduncles.

35. Transverse band under the optic nerve.

36. Transverse band of the bundles which go to the middle lobe.

37. Transverse band of the great superior ganglion.

38. Place where the diverging and uniting fibres decussate.

39. Anterior fold of the corpus callosum.

40. Posterior fold of the corpus callosum.

41. Upper surface of the primary part of the cerebellum.

42. Inferior surface of the primary part of the cerebellum.

43. Tubercle of the fourth ventricle in fishes.

44—45. Cerebral convolutions behind the great fissure of Sylvius.

46. Soft or middle commissure.

47—48. Situation of the organ of amativeness.

48—49. Situation of the organ of inhabitiveness.

50—51. Situation of the organ of self-esteem.

51—52. Situation of the organ of firmness.

52—53. Situation of the organ of veneration.

53—54. Situation of the organ of benevolence.

54—55. Situation of the organ of comparison.

55—56. Situation of the organ of eventuality.

57, 58, and 59. Septum lucidum.

60. Fornix.

61. Anterior commissure.

62. Interior of the nervous substance of the cerebellum.

63. White fibres, which unite with the septum lucidum.

65. Horizontal section of the cerebellum.

70. Nervous bundles of the organs of the affective faculties.

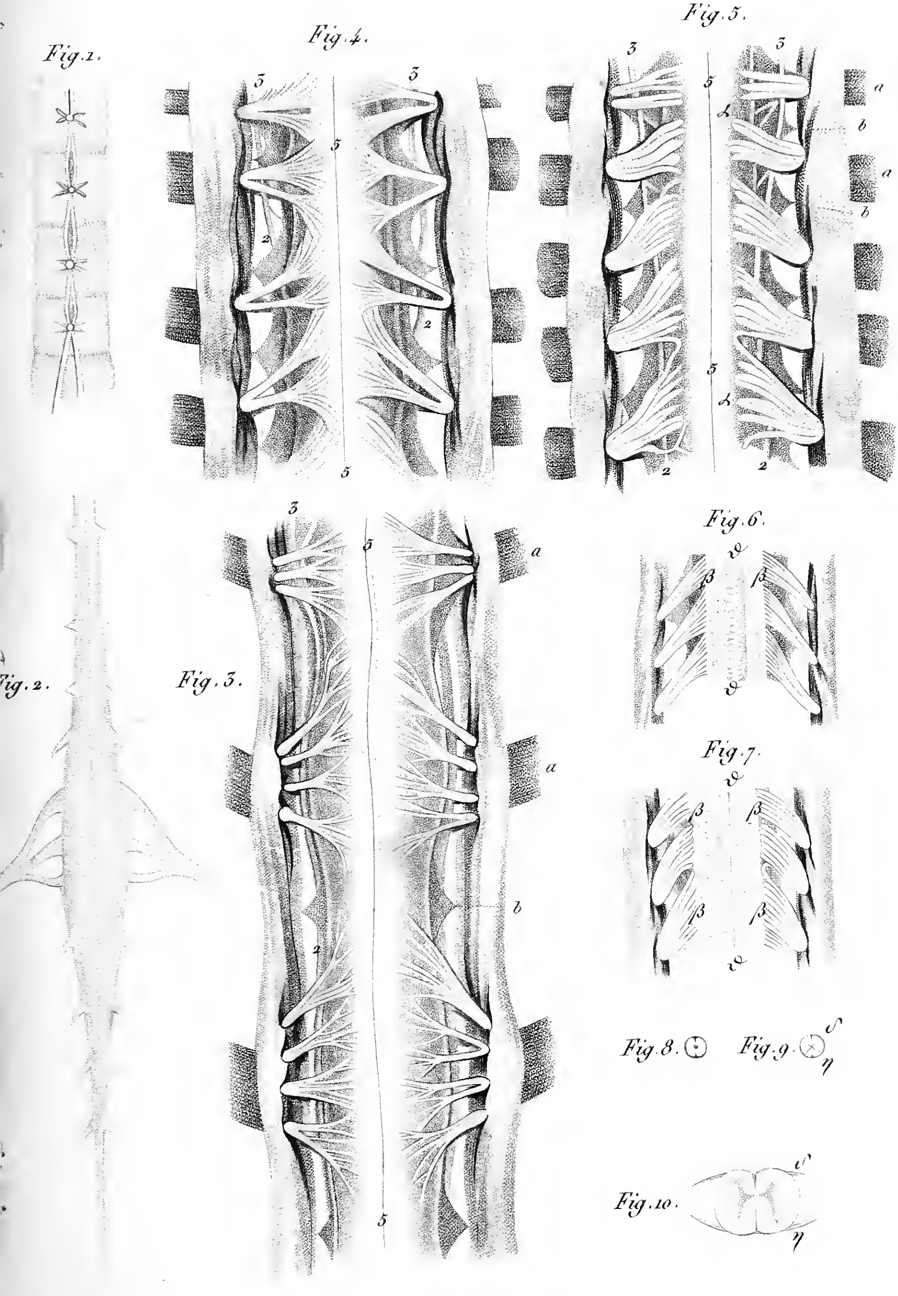
86, 87, 88, 90. Intermedial layers of fibres between the two halves of the cerebral masses.

I. Organ of Amativeness.
II. . . Philoprogenitiveness.
III. . . Inhabitiveness.
IV. . . Adhesiveness.
V. . . Combativeness.
VI. . . Destructiveness.
VII. . . Secretiveness.
VIII. . . Acquisitiveness.
IX. . . Constructiveness.
X. . . Self-esteem.
XI. . . Love of approbation.
XII. . . Cautiousness.
XIII. . Benevolence.
XIV. . . Veneration.
XV. . . Firmness.
XVI. . . Conscientiousness.
XVII. . Hope.
XVIII. . Marvellousness.
XIX. . Ideality.
XX. . . Mirthfulness.
XXI. . . Imitation.

XXII. Organ of Individuality.
XXIII. . . Configuration.
XXIV. . . Size.
XXV. . . Weight and resistance.
XXVI. . . Colouring.
XXVII. . . Locality.
XXVIII. . . Calculation.
XXIX. . . Order.
XXX. . . Eventuality.
XXXI. . . Time.
XXXII. . . Melody.
XXXIII. . . Language.
XXXIV. . . Comparison.
XXXV. . . Causality.

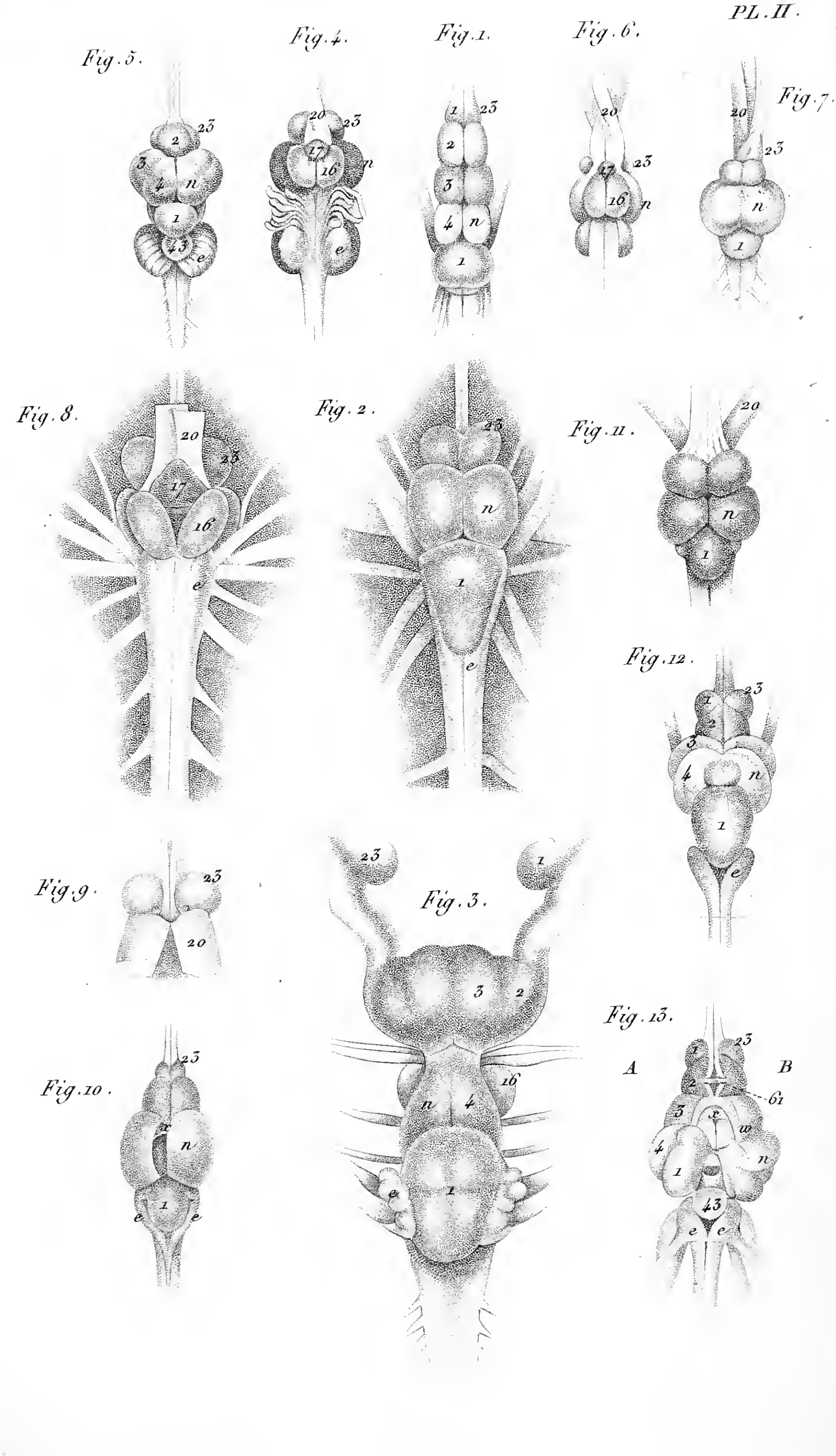
THE END.

LONDON;
Printed by William Clowes,
Northumberland-court.



Published by Dr. Spurzheim 1826

PL. II.



Published by Dr. Spurzheim 1826

Fig. 1.

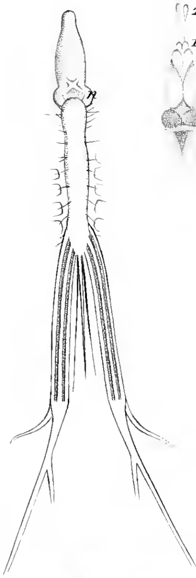


Fig. 2.

Fig. 3.

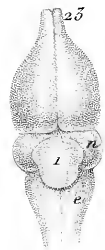


Fig. 4.

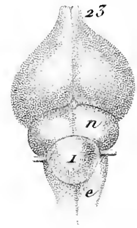


Fig. 5.

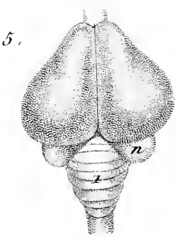


Fig. 6.

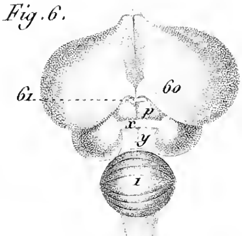


Fig. 7.

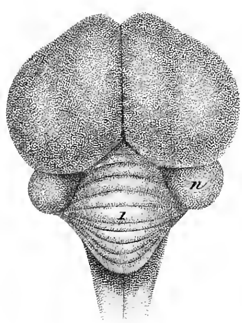
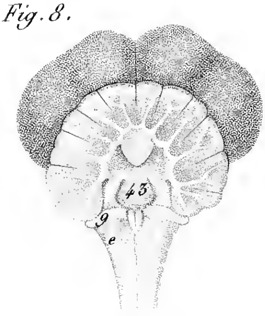


Fig. 8.



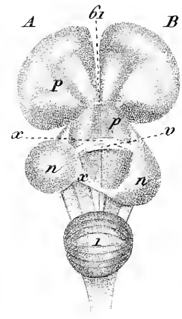


Fig. 9.

Fig. 10.

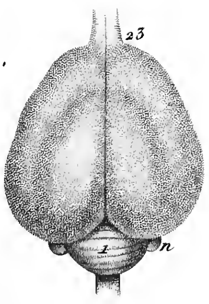


Fig. 11.

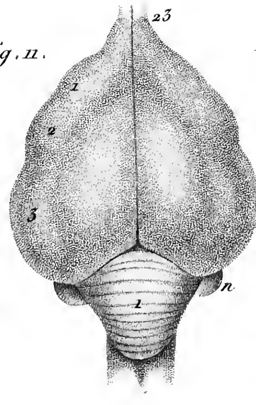
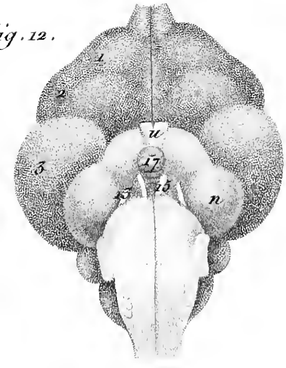


Fig. 12.



Published by Dr. Spursheim 1826

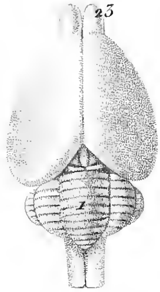


Fig. 1.

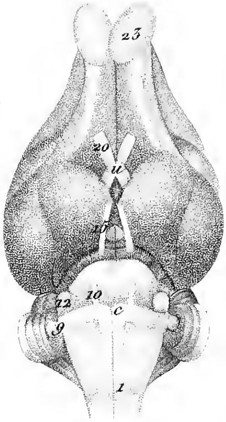


Fig. 2.

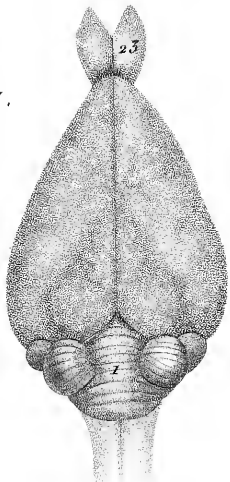


Fig. 3.

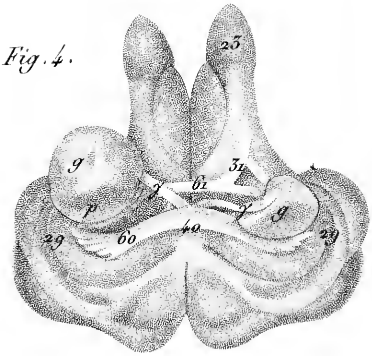


Fig. 4.

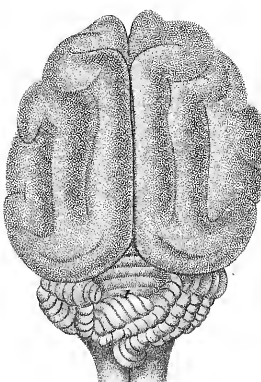


Fig. 5.

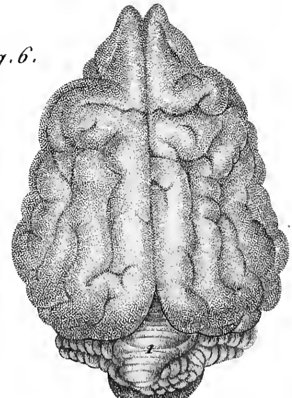


Fig. 6.

Published by Dr. Spurzheim 1826

Fig. 6.

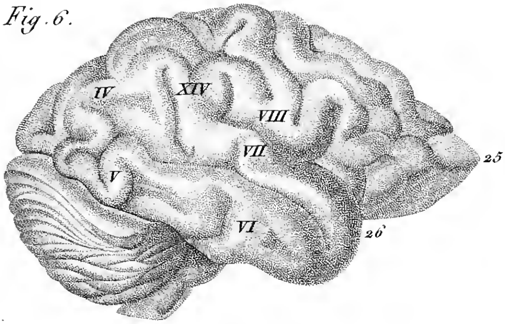


Fig. 2.

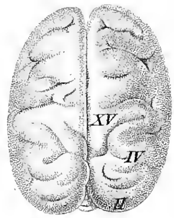


Fig. 5.

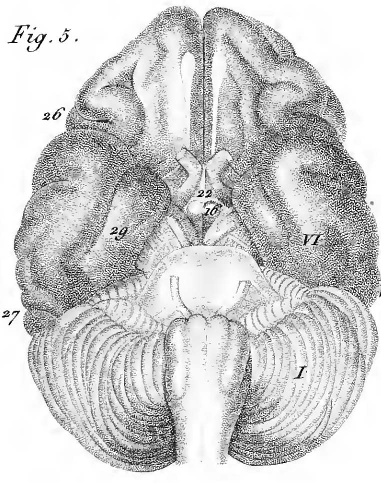


Fig. 3.

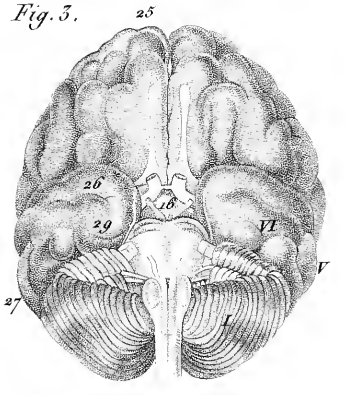


Fig. 4.

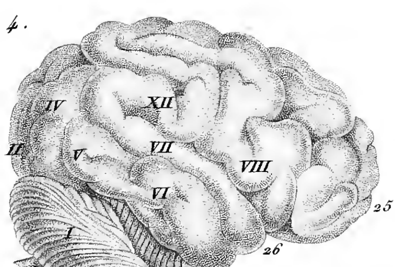
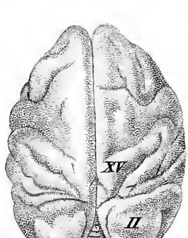


Fig. 1.



Published by Dr. Spurzheim 1826

Fig. 1.

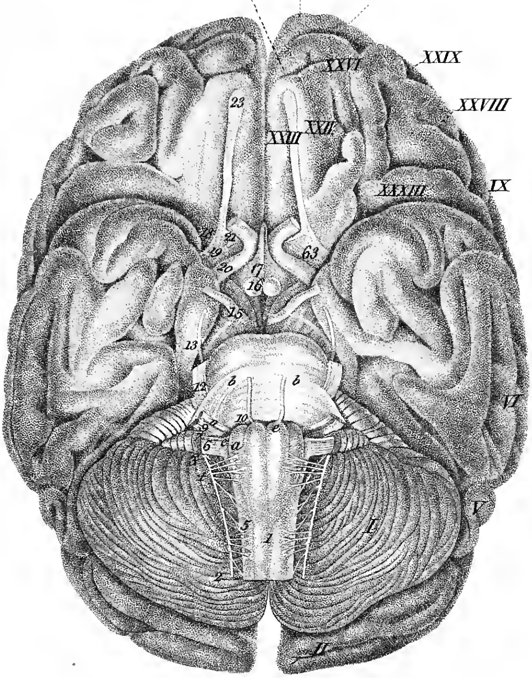
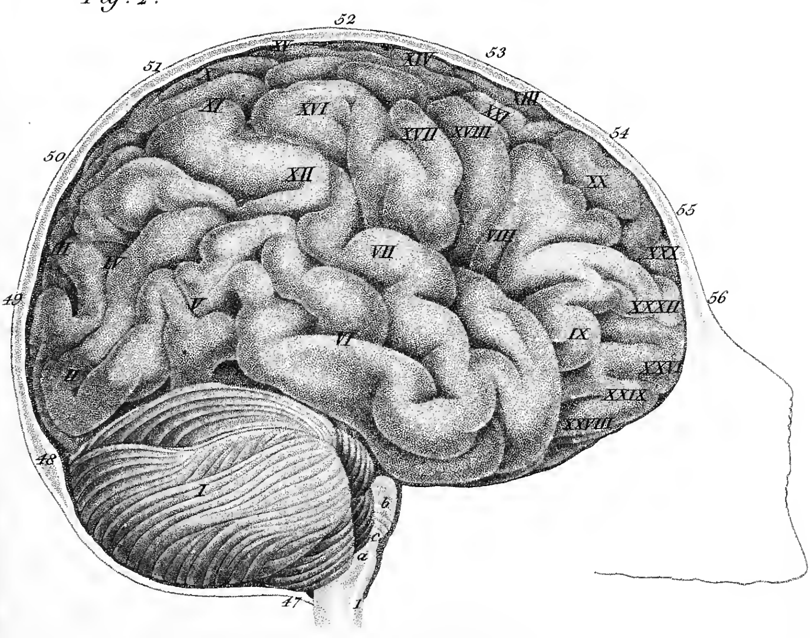


Fig. 2.



Published by Dr. Spurzheim 1826

Fig. 1.

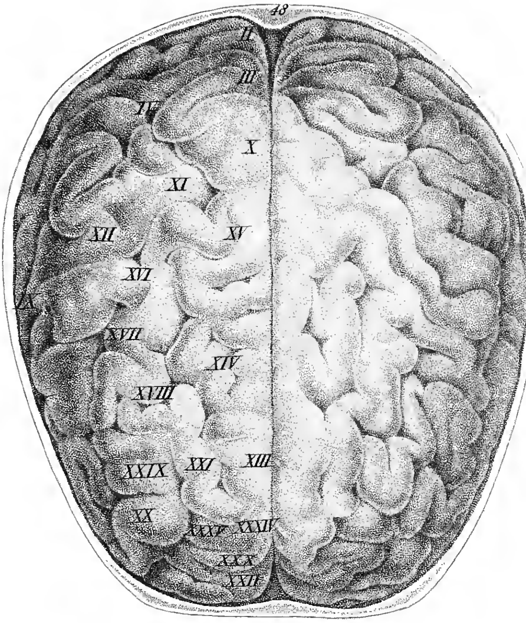
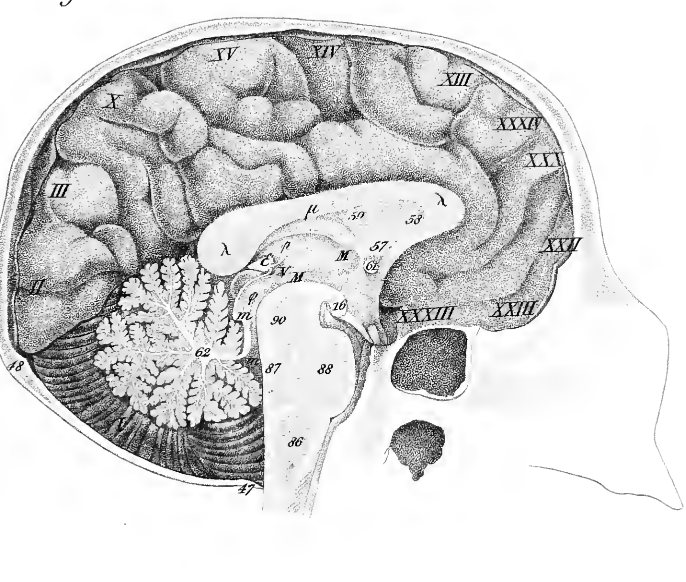


Fig. 2.



Published by Dr. Spurzheim 1826

Fig. 1.

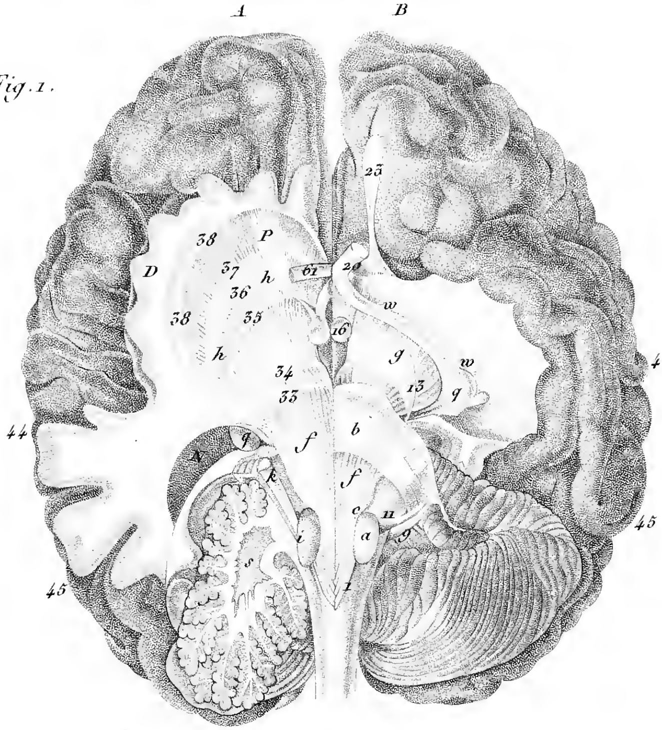
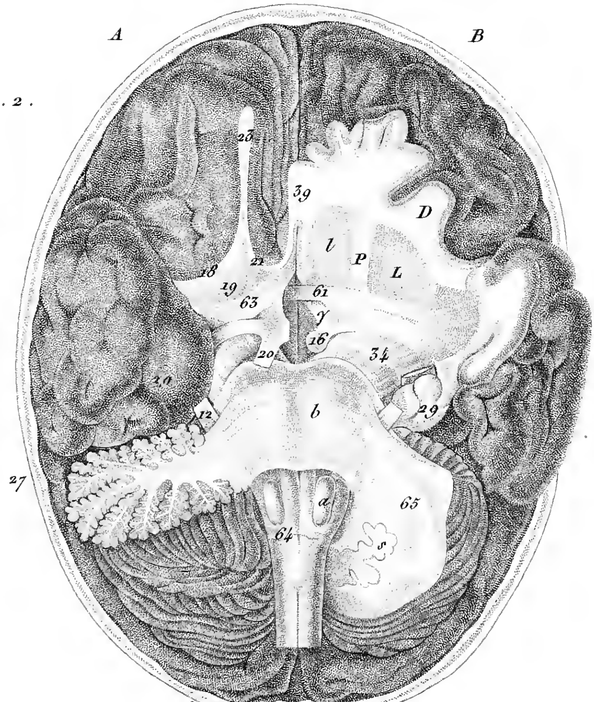


Fig. 2.



Published by Dr. Spurzheim 1826

Fig. 1.

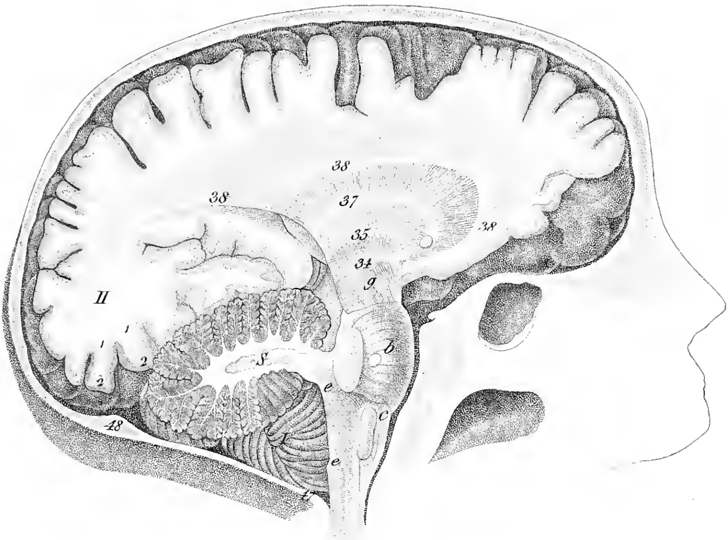
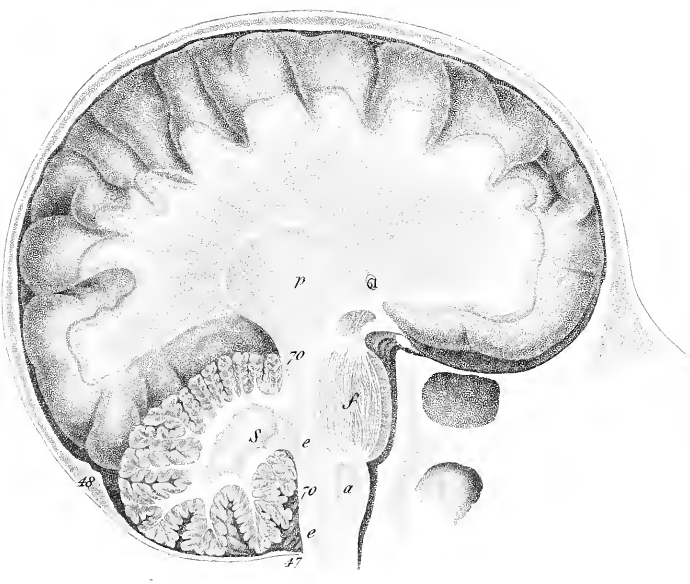


Fig. 2.



Published by Dr. Spurzheim 1826

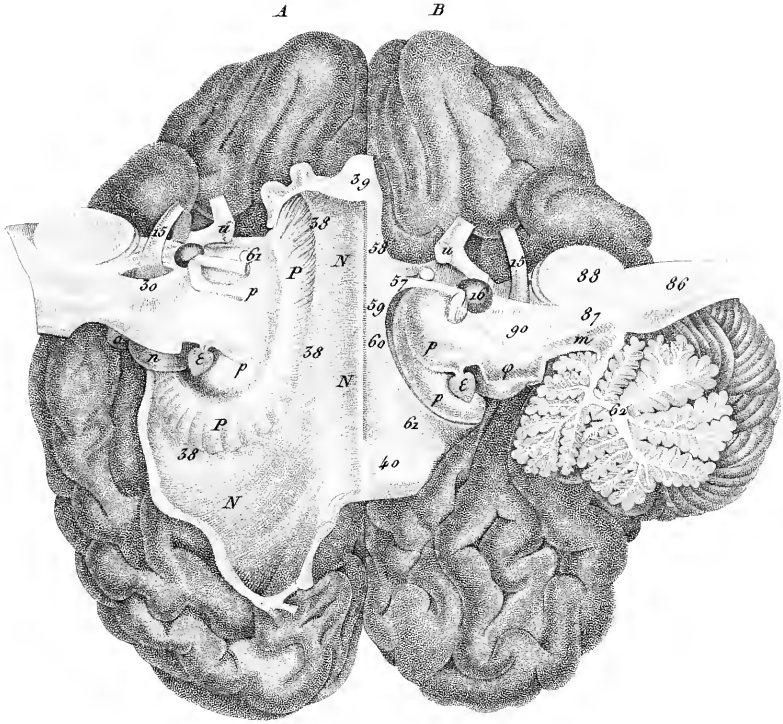


Fig. 1.

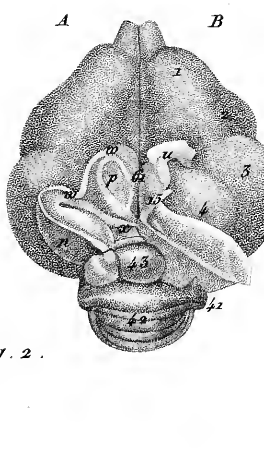


Fig. 2.

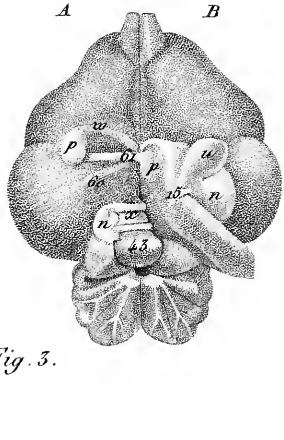


Fig. 3.

Published by Dr. Spurzheim 1826.

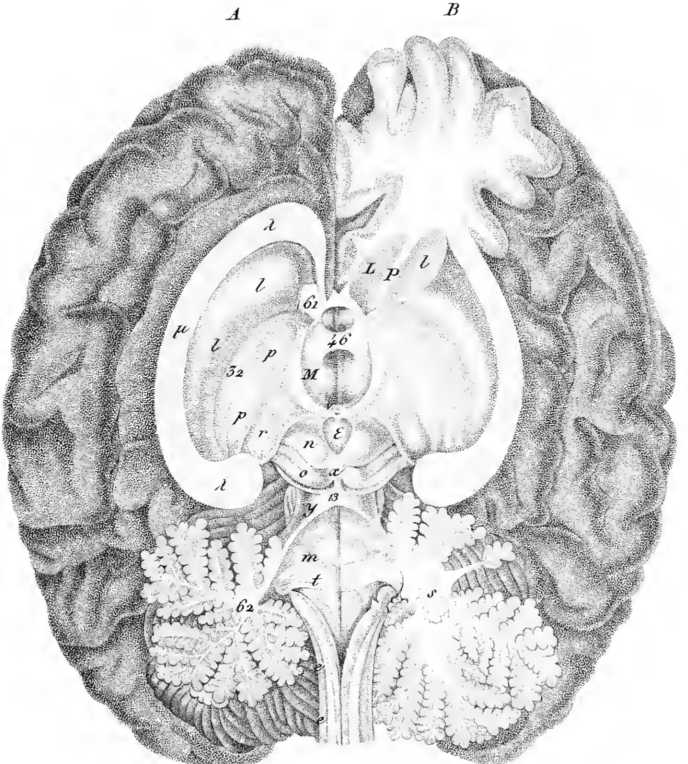


Fig. 1.

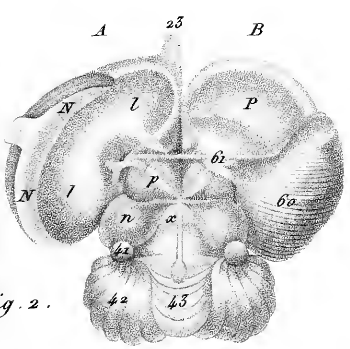


Fig. 2.

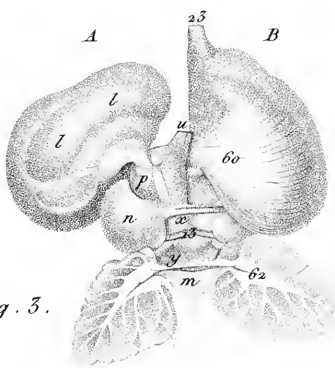


Fig. 3.